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FOOD

AND THE

PRINCIPLES OF DIETETICS

BY

ROBERT HUTCHISON, M.D., Edin., M.R.C.P.

ASSISTANT PHYSICIAN TO THE LONDON HOSPITAL AND TO THE HOSPITAL FOR SICK CHILDREN, GREAT ORMOND STREET

WITH PLATES AND DIAGRAMS

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many able systematic writers on the subject who have preceded him, both in this country and on the Continent, and whose names are too well known to require special mention here. He would like, however, to take this opportunity of expressing his special indebtedness to the work and writings of Professor Atwater and his colleagues in America, who have done so much in recent years to advance our knowledge on the principles of dietetics. The opening chapters, especially, of the present book owe much to the teaching of the American school.

To Dr. Leonard Hill and the writer's other colleagues at the London Hospital Medical College he must express his gratitude for much encouragement and useful advice, and to his friends Dr. J. J. R. Macleod and Mr. Robert Tanner he is indebted for the pains which they have bestowed on the revision of the proof-sheets.

The illustrations have been drawn by Mr. Danielsson with his usual skill, and the care with which Mr. Archibald Clarke has compiled the index has saved the author much labour.

LONDON, *October*, 1900

TO THE

STUDENTS OF THE LONDON HOSPITAL

TO WHOM ITS CONTENTS WERE FIRST ADDRESSED,

AND BUT FOR WHOSE ENCOURAGEMENT

IT WOULD NOT HAVE APPEARED IN ITS PRESENT FORM,

THIS VOLUME IS DEDICATED

BY

THE AUTHOR.

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PREFACE.

The contents of this book were first addressed to the students of the London Hospital in the form of a course of lectures about a year and a half ago. The very gratifying reception accorded to these lectures and the almost total neglect of the subject of dietetics in ordinary medical education have induced the author to publish them in their present form.

While the book has been specially designed to meet the requirements of students and practitioners of medicine, it is hoped that it may also prove intelligible and interesting to anyone desiring to acquire some knowledge of foods and the difficult problems of nutrition.

In recasting the lectures for publication a large amount of additional material has been used, and no pains have been spared to make the book fully representative of the present state of our knowledge on the subject of which it treats. A considerable amount of space has been devoted to the patent and proprietary foods, and an effort has been made to deal fairly and honestly with their merits. The great number and variety of these now offered for sale makes this specially necessary.

As far as possible original papers have always been consulted, and references to these will be found in the footnotes; but if, as is only too probable, some important publications have been overlooked, the vast extent of the literature of the subject must be taken as the author's excuse.

The author feels also that he is under a great obligation to the

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FOOD AND DIETETICS

CHAPTER I

THE NATURE, NUTRITIVE CONSTITUENTS, AND RELATIVE VALUES OF FOODS

A food may be defined as *anything which, when taken into the body, is capable either of repairing its waste or of furnishing it with material from which to produce heat or nervous and muscular work.*

I am aware that this definition is open to criticism, as most definitions of the term have been before it, and that it is difficult to refuse to oxygen especially the right to be regarded as a food under the terms of such a description. But for practical purposes the definition may be allowed to stand, and it has the advantage of bringing into prominence the two main functions of food—in the first place, as a provision for the growth and repair of the fabric of the body, and, secondly, as a source of potential energy which can be converted into heat and work. In virtue of the former function, food provides for the conservation of the material of the body; the conservation of bodily energy is maintained by the latter.

Substances which are unable to help in either of these directions may have a useful place in the dietary, but they cannot be truly regarded as foods. Examples of such substances are to be found, as we shall learn later, in tea, coffee, and the extractives of meat.

Most ordinary articles of diet are not simple bodies; they are made up of mixtures of various chemical substances, some of which are of nutritive value, others not. The former may be spoken of as

the **nutritive constituents** or 'nutrients,' and may be classified as follows:

Organic	1. Nitrogenous[1]	Proteids, *e.g.*, casein, myosin, gluten, legumin.
		Albuminoids, *e.g.*, gelatin.
	2. Non-nitrogenous	Carbohydrates, *e.g.*, sugar, starch.
		Fats, *e.g.*, olive-oil, butter.
Inorganic	Mineral matters, *e.g.*, sodium, potassium, lime, phosphorus, chlorine.	
	Water.	

Any article of diet, even the most elaborate product of the cook's art, can be shown, by chemical analysis, to contain one or more of the members of these different groups; otherwise it is not a 'food' at all.

The functions of food are fulfilled by the different groups in different measure. The first function, that of building up and repairing the tissues, can be fulfilled by the proteids and by the inorganic constituents, and by these alone. For this purpose proteid, mineral matters, and water are all necessary. None of the three is sufficient by itself. The second function, that of serving as a source of potential energy, is the property of all the organic constituents, although there is a limited sense in which water, and even, perhaps, the mineral constituents, may be regarded as sources of energy too (see p. 277).

The comparison of the body to a steam-engine is a rather threadbare and not altogether accurate analogy, but it is, perhaps, the best that can be found. The building material of food corresponds to the metal of which the engine is constructed, the energy-producers to the fuel which is used to heat the boiler. Where the body differs from the engine is that it is able to use part of the material of its construction (proteid) for fuel also.

In regard to the relative values of the organic constituents as energy-producers, physiological opinion has undergone considerable changes in the last fifty years. It used to be supposed, mainly as the result of the powerful advocacy of Liebig, that the proteids were the chief producers of muscular energy, while the carbohydrates and fats merely acted as fuel and maintained the body temperature. We now know that this was a mistaken view. It would seem, indeed, to be to a large extent a matter of indifference to the *cells* of the body whether they draw their supplies of energy from proteid, albuminoids,

[1] In describing the nitrogenous nutritive constituents of foods, I have made use of the terminology now commonly employed in chemical physiology. Some writers use the term 'protein,' as covering the whole group of nitrogenous nutritive constituents; others use the word 'albuminoids' where 'proteids' is employed above, and speak of gelatin and its allies as 'gelatinoids.' The nitrogenous 'extractives' have not been included in the above classification, because they have no nutritive value.

carbohydrate, or fat, although probably they can get it more rapidly and easily from the three former than from the latter. We now know also that bodily heat is not a thing apart and requiring to be provided for by itself, but that it is an inevitable accompaniment of cell life. Life and heat are inseparable, and in fulfilling its other functions in the body a cell cannot help producing heat also. Heat, in fact, is a by-product of functional activity (see also p. 49). Hence it is a matter of indifference as far as the cells of the body are concerned—not necessarily, be it remembered, as far as concerns the digestive organs—whether we feed a man on egg-white, gelatin, butter, or sugar, always supposing that these are supplied in the proportion of their dynamic equivalents.

As regards the manufacture and repair of tissue, however, no such indifference prevails. That can be done by proteid, mineral matters, and water, and by these alone. Even the albuminoids, near though they stand to the proteids, and large though the proportion is in which they enter into the bodily framework, can take no share in tissue formation. This is true, curiously enough, even of the connective tissues, from which gelatin is itself derived.

One may therefore classify the nutritive constituents of food, in accordance with their functions in the body, as follows:

Tissue-formers.	*Work and Heat Producers.*
Proteids.	Proteids.
Mineral matters.	Albuminoids.
Water.	Carbohydrates.
	Fats.
	? Mineral matters.
	? Water.

It will be observed that proteids alone are able to fulfil both of the functions of a food. It is this physiological omnipotence which gives to proteids their vast importance in the diet, and justifies the proud title of 'pre-eminent' which the name implies. Without proteid life is impossible, for the daily wear and tear of tissue must somehow be made good. With proteid, plus water and some mineral salts, life can be healthily maintained for a practically indefinite time, as is proved by the experience of tribes such as the Indians of the Pampas, who live year in year out on nothing but lean beef and water.

Such being the uses of foods in the body, the question arises, How is one to judge of their relative value? By what criteria is one to decide whether any particular article of diet is a good food or not? The reply is that such a question can only be decided by submitting the food under consideration to these **four tests**:

1. *Chemical.*—What percentage of each nutritive constituent does the food contain?

2. *Physical.*—How much potential energy is it capable of yielding?

3. *Physiological.*—How does it behave in the stomach and intestine? Is it easily digested, and to what extent is it absorbed?

4. *Economic.*—Are the nutritive constituents which the food contains obtained at a reasonable cost?

We must now proceed to consider the methods by which each of these tests is applied.

1. **The Chemical Test.**—Chemical analysis can tell us how much of each nutritive constituent (proteid, carbohydrate, etc.) a hundred parts of the food contain. Armed with this information, we can arrive at an idea of the value of the food as a source of building material or energy. In subsequent chapters the percentage composition of all the chief articles of food will be brought forward in detail, and I shall refer to some types of these immediately.

2. **The Physical Test.**—Ever since Lavoisier showed that the changes which food undergoes in the body are essentially changes due to oxidation, the idea has gathered weight that the amount of heat which a food is capable of yielding on complete combustion may be taken as a measure of its value as a source of energy, for heat and work are convertible terms. Now, the standard of heat production is the calorie, which means the amount of heat required to raise the temperature of 1 gramme of water 1° C. This is the small calorie. For measuring the heat value of foods, one employs for convenience the large, or Kilo-calorie—*i.e.*, the amount of heat required to raise 1 kilo (or 1 litre) of water 1° C., or, which is the same thing, 1 pound of water 4° Fahr.; and one writes it **Calorie**, with a capital letter. All that one has to do in applying this test is to ascertain of how many litres of water the complete combustion of 1 gramme of the food under consideration is able to raise the temperature by 1° C. The result gives the value of 1 gramme of the food in terms of Calories. A large number of very careful experiments of this sort have been made in recent years with the aid of the bomb-calorimeter, the results of which are graphically represented in the following diagram (Fig. 1.).

The suspicion naturally arises that, although these results hold good for combustion outside the body, they may not be equally true for combustion in the tissues. This suspicion is strengthened when one remembers that many of the waste products of metabolism, such as urea, are by no means completely oxidized. The body does not reduce all its fuel to the condition of ashes; some of it is only

charred. Careful observations by Rubner, however, have shown that, if allowance is made for these incompletely oxidized products, combustion inside the body is precisely the same, as far as the amount of energy liberated is concerned, as combustion in an ordinary furnace, and that the heat value of 1 gramme[1] of each of

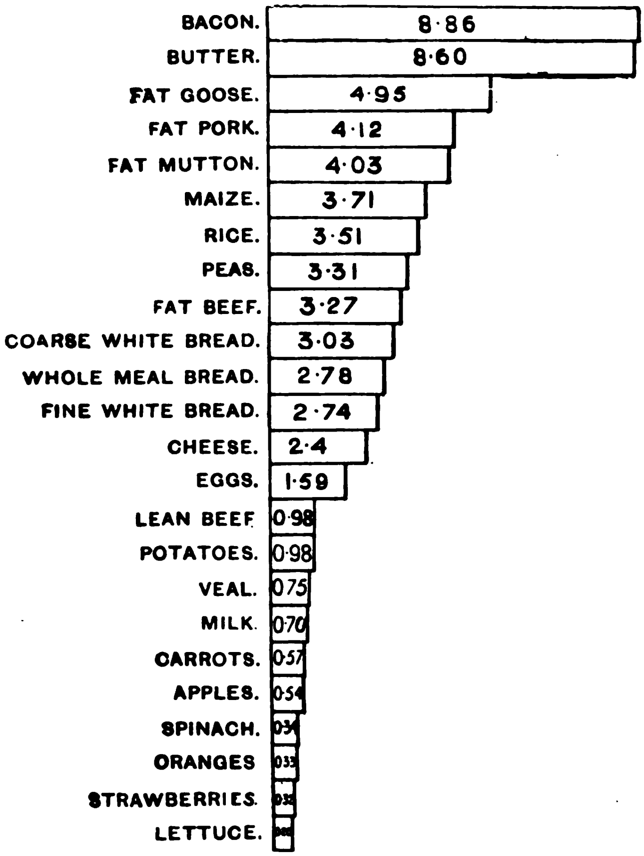


FIG. 1.—NUMBER OF CALORIES YIELDED BY THE COMPLETE COMBUSTION OF ONE GRAMME OF VARIOUS FOODS.

the three chief nutritive constituents of food when taken into the tissues is as follows:

Proteid	4·1 Calories.
Carbohydrates	4·1 „
Fat	9·3 „

[1] A gramme = 15½ grains. A shilling weighs about 5½ grammes.

The white of one egg contains 4 grammes of proteid, a small lump of sugar contains the same weight of carbohydrate, and a thimbleful of olive-oil a similar amount of fat, so that the latter will yield twice as much energy in the body as the white of a whole egg or a small lump of sugar.

In the Calorie, then, we have a standard which is as applicable in estimating the energy value of foods as the foot-rule is in measuring length or the ounce in calculating weight. But great as the value of this standard is—and, indeed, it is the only absolute standard by means of which all foods may be compared—one must not over-estimate it. Just as in a furnace some substances, such as anthracite, are 'slow,' and others, such as petroleum, are 'quick' fuels, so in the human body some of the nutritive constituents seem to yield their energy to the cells more rapidly than others. Thus, proteids, carbohydrates, and albuminoids seem to be oxidized quickly in the tissues, fats more slowly. And this is not a matter of indifference, for if a rapid output of energy i. required, the first group will be more serviceable, whereas a slow production over a long time will be equally well met by fat (see also p. 40). Further than this, the situation in which the energy is liberated must also be taken into account. It may be a matter of indifference, as far as the heat produced is concerned, whether oxidation takes place in the liver or in the muscles; but as regards the bodily function, of which, as we have seen, the production of heat is but an accompaniment, there is all the difference in the world. The time and the place, in short, have to be considered, as well as the actual amount of the energy liberated. The physical test of a food enables us to judge of the latter; it tells us nothing of the two former.

The **method of applying the Calorie standard** to a food is very simple. One has merely to multiply the percentage of proteid or carbohydrate which it contains by 4·1, and the percentage of fat by 9·3, to get the total Calories yielded by 100 parts of the food in question. Suppose, for example, that a specimen of milk contains in every 100 grammes 2 per cent. of proteid, 4 per cent. of fat, and 6 per cent. of carbohydrate, then the Calories yielded by that quantity of milk would be as follows:

Proteid	$2 \times 4{\cdot}1 = 8{\cdot}2$
Fat	$4 \times 9{\cdot}3 = 37{\cdot}2$
Carbohydrate	$6 \times 4{\cdot}1 = 24{\cdot}6$
Total Calorie value of 100 grammes of the milk ..	70·0

In Plate I. there is represented the number of Calories contained in 1 pound of some typical foods, and the proportions of these

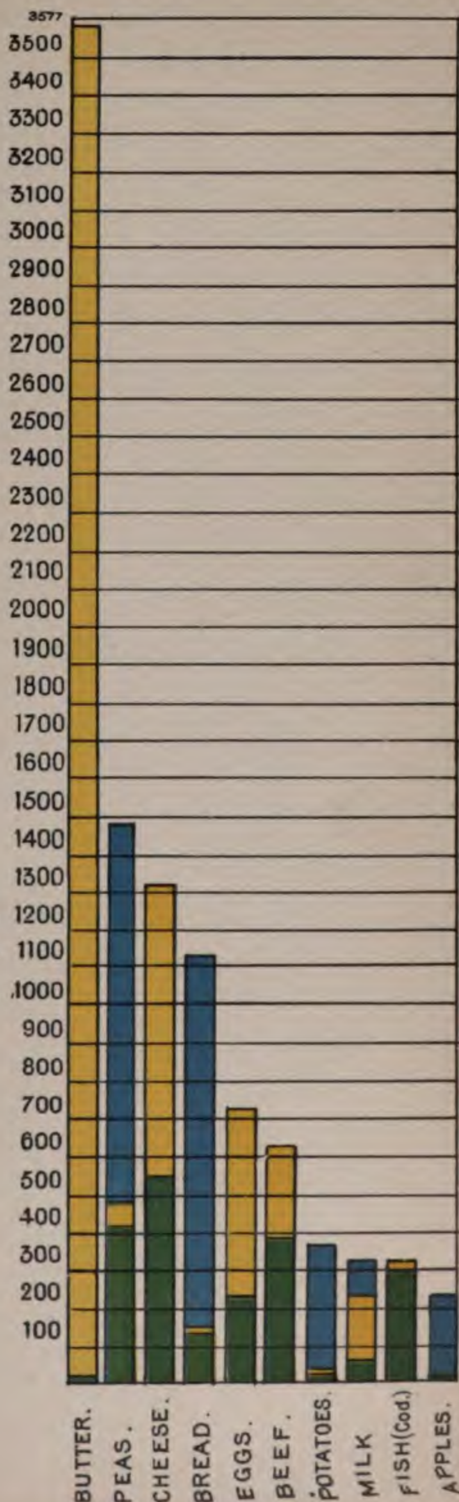
Plate I

FUEL VALUE OF ONE POUND OF SOME TYPICAL FOODS.

The diagram represents the relative number of Calories obtained from each food in the form of proteid (green) fat (yellow), and carbohydrate (blue) respectively. The following are the exact figures from which it has been constructed:

Food.	Calories as Proteid.	Calories as Fat.	Calories as Carbo-hydrate.	Total Fuel Value per Pound.
Butter ..	18	3,559	none	3,577
Peas ..	418·8	71·7	982·5	1,473
Cheese ..	553	750	none	1,303
Bread ..	130	21·5	976·5	1,128
Eggs ..	232	507	none	739
Beef ..	391	232	none	623
Potatoes	18·5	9·3	341·2	369
Milk ..	67	168	87	322
Fish (cod)	299	16	none	315
Apples ..	9	none	229	238

The number of Calories yielded by each ingredient has been calculated from the average percentage composition of the different foods as given in subsequent pages. It is assumed that the whole of each article is edible, and no allowance is made for defective absorption.



which are yielded by proteid, fat and carbohydrate respectively. It will be noticed that butter heads the list as far as the total number of Calories yielded is concerned. This is due to the large amount of fat which it contains. In potatoes, on the other hand, the Calories yielded are mainly derived from carbohydrates, while in cheese and beef the total yield is produced by proteid and fat in nearly equal proportion. In other words, as a producer of energy, a pound of butter is worth about three times as much as a pound of cheese, and more than five times as much as a pound of beef; but as a source of building material both cheese and beef are vastly superior to it.

3. **The Physiological Test.**—It is not enough that a food should contain a considerable proportion of proteid, carbohydrate and fat, and should be capable of yielding energy on oxidation. It must also be of such a nature that it can be easily digested in the stomach, and more or less completely absorbed into the blood. Such substances as sawdust, petroleum and hoof-parings might pass the chemical and physical tests easily enough, but they are of no use in the body, for they cannot be digested and absorbed. For this reason the behaviour of a food in the stomach and intestine must be reckoned with before any opinion can be pronounced as to its value in the diet.

In studying this subject, one must distinguish very clearly between the meaning of the term 'digestibility' in its popular sense and the significance which is attached to it by physiologists. When one speaks of a food as being 'indigestible,' one ordinarily means that it is a food which is apt to produce feelings of pain and discomfort in the stomach. When a physiologist uses the same term, he usually means that the food to which it is applied is one which is only imperfectly absorbed into the blood. Cheese is an indigestible food in the former, and green vegetables in the latter, sense. To avoid confusion, it is better to adhere to the popular usage of the expression 'digestibility,' and, if one may use a rather ugly word, to employ the term 'absorbability' to indicate the completeness with which the constituents of a food can pass from the intestine into the circulation.[1]

By a **digestible food**, then, I mean one which is disposed of by the stomach with little trouble, and without producing any feelings of discomfort, pain or uneasiness. The only absolute criterion of the digestibility of a food in that sense is the length of time which it

[1] In this nomenclature 'digestibility' would correspond to the German *ertragbarkeit*, and 'absorbability' to *ausnutzbarkeit*.

has to remain in the stomach before it is fit to be passed on into the intestine. The shorter time a food requires to stay in the stomach, the greater is its digestibility; and the longer the period which must elapse before it can pass on into the intestine, the more indigestible the food is.

In a subsequent chapter we shall have occasion to study the results of a large number of exact experiments which have been performed to ascertain the length of time which different foods remain in the stomach—experiments, that is to say, on the comparative digestibility of foods. I would only point out here some of the factors which are of importance in determining the length of time required in any particular case. It must be borne in mind that one of the chief duties of the stomach is to reduce the food to a fluid or semi-fluid condition. The more difficult the process of solution is, the longer must the food remain in the stomach. Now, bulky foods, those of a dense and firm consistency and those which contain a large proportion of solid matter, will take longer to dissolve, and will consequently remain longer in the stomach than foods of opposite properties. Obviously, then, foods of such a character may be regarded as comparatively indigestible. In addition to these factors, certain others must be taken into account, such as the proportion of fat which the food contains, its temperature, and the presence or absence of substances in it which are capable of exciting the secretion of the digestive fluids. All of these will be fully considered later on.

Before leaving this subject, mention must be made of one other quality of foods which seems specially to affect the stomach, and which, for want of a better term, is commonly called their **satisfying power.** It is a matter of common knowledge that some foods appease the appetite and allay the feelings of hunger longer than others. Such foods are said to be 'satisfying,' or, to use a slang expression, 'stodgy.' What it is which confers this quality upon some foods rather than others is not perfectly clear; but there is reason to believe that it depends to some extent upon the amount of fat which the food contains. Foods rich in fat are more satisfying than others. It is believed to be for this reason that eggs possess the quality under consideration in no ordinary degree. Other properties, such as the amount of solid matter to be digested and the bulk of the food, no doubt play a part in producing the feeling of 'satisfaction' also; but whatever the explanation of the quality is, it has certainly to be reckoned with in estimating the value of a food from the stomach point of view.

ABSORBABILITY.

A large number of experiments have been performed in recent years in order to ascertain the degree to which the different constituents of various foods are absorbed into the blood. Most of these experiments have been carried out on the Continent, but a few have also taken place in America. The results are summarized (in round numbers) in the following table, constructed from the figures of Rubner[1] and Atwater[2]:

ABSORBABILITY OF DIFFERENT FOODS.

	PER CENT. ABSORBED.			
	Dry Substance.	Proteid.	Fat.	Carbohydrates.
Meats and fish	95	Practically all	79 to 92	—
Eggs	95	Practically all	96	—
Milk	91	88 to 100	93 to 98	?
Butter	—	—	98	—
Margarine	—	—	96	—
Fine wheat bread	95½	81 to 100	?	99
Decorticated whole wheat bread	88	69½	?	92½
Maize meal	93	89	?	97
Macaroni	95	81	?	97½
Rice	96	84	?	99
Peas	99	82½	?	96½
Beans	82	70	—	?
French beans	85	—	—	—
Potato purée (in small quantities)	—	80½	—	Practically all
Potatoes in general	80½	70	—	92½
Cabbage	85	81½	—	84½
Carrots	79	61	—	82
Beetroots	—	72	?	82

The method of experiment consists in analysing the food to be investigated, and then ascertaining, from an examination of the fæces, the proportion of its proteid, carbohydrate and fat which escapes absorption.

A little consideration will show that there is here a source of fallacy. The fæces consist not merely of the remains of unabsorbed food, but also, and to a very considerable extent, of the residues of the digestive juices and the débris of epithelial cells. In the case of the nitrogen and fat of the fæces, at any rate, one cannot tell what proportion is derived from the one source and what from

[1] Leyden's 'Handbuch der Ernährungstherapie,' i. 115.
[2] 'The Chemical Composition of Food Fishes,' Washington, 1891, p. 825.

the other. So uniform, indeed, is the percentage composition of the excreta under all diets that some writers[1] prefer to speak of foods as large or small fæces-producers, rather than as being capable of incomplete or complete absorption. After all, the matter is one of academic rather than practical interest. The important point is that on some diets more nitrogen and fat are excreted from the body than on others. Whatever the source of these, they are equally indicative of loss to the body. One is therefore quite justified in representing the loss as if it represented food material unabsorbed. In the accompanying diagram (Plate II.) there is shown the percentage of each nutritive constituent which is unabsorbed in some typical foods. It will be well to consider each constituent separately.

1. *Absorption of Proteids.*—One of the first points which arrest the attention on looking at the diagram is that, of the three chief nutritive constituents, the proteids are the least completely absorbed. Whether this is quite an accurate way of stating the case, whether one should not rather say that foods differ more in regard to the waste of nitrogen which they cause than in any other respect, is, as has been shown, a matter of indifference. The fact remains that with some of the foods much nitrogen is excreted in the fæces, with others little. Closer inspection will show that in this respect foods may be divided into two groups. On a purely animal diet (milk, eggs, beef) there is but little nitrogen lost; when vegetable foods are taken (carrots, potatoes, peas, etc.) the waste of nitrogen is very considerable, amounting as it does in the case of carrots to nearly 40 per cent. of the total proteid consumed. The reason for this loss of proteid on a vegetable diet will be considered later (p. 164), but it must be pointed out in this place that the smaller the amount of nitrogen a food contains, the greater is the apparent loss of it in the fæces, for the higher is the ratio of the nitrogen derived from the digestive juices to that in the food. This explains, to some extent at least, the great apparent loss of proteid in such foods as carrots and rice.

2. *Absorption of Fat.*—Compared with the proteids, fat is apparently very completely absorbed. This probably means that the residue of the intestinal juices contains almost no fat; hence nearly all that which appears in the fæces is derived from the unabsorbed of the food. In the case of most of the vegetable foods, the am of fat which they contain is so small that its absorption cann accurately estimated.

[1] See Prausnitz, *Zeitsch. f. Biologie*, Bd. 35, p. 287, 1897.

Regarding the absorbability of fat, one generalization can be made with a fair amount of certainty, and it is this: the lower the melting-point of the fat, the more completely is it absorbed. The explanation of this, of course, is that a fat which is fluid at the body temperature is more easily taken up into the blood than one which remains more or less solid. The following are illustrative examples:

Fat.	*Melting-point.*	*Percentage unabsorbed.*
Butter	37° C.	$2\frac{1}{2}$
Bacon	48° C.	8
Mutton-fat	52° C.	10

The total amount of fat which can be absorbed in one day is a matter of some interest. It has been found by experiment that 150 grammes (about $5\frac{1}{2}$ ounces) can be absorbed without appreciable loss. Above this point the waste increases considerably, but even when twice that quantity is taken the loss is less than 45 per cent. The practical deduction from these facts is that one need have no hesitation in ordering a patient, say a diabetic, to consume $\frac{1}{4}$ pound of butter every day. There is no likelihood of this quantity surpassing the absorptive powers of the intestine.

3. *Absorption of Carbohydrates.*—As is clearly shown in the diagram, the carbohydrates are more completely absorbed than any other nutritive constituent of the food. Sugar probably never fails to enter the blood to the last grain, and even starch only reappears in the fæces when taken in a form specially difficult of absorption, such as in green vegetables or in coarsely divided masses. Hence it is that foods which consist mainly of carbohydrates, such as rice, leave, on the whole, less solid residue in the intestine than any other, animal foods not excepted. In other words, the statement sometimes made, that vegetable are less perfectly absorbed than animal foods, is not universally true, although it may hold good in the majority of cases.

Seeing that a given weight of fat represents about two and a quarter times as much energy as an equal weight of proteid or carbohydrate, it is evident that the loss to the body of a given amount of fat through non-absorption is of more importance than an equal loss of any of the other nutritive ingredients. For this reason it is perhaps more instructive to represent the percentage of the total Calories which a food contains which are lost in this way, rather than to give, as has been done above, the actual loss of each constituent. Adopting this plan, it will be found that the loss in some typical foods is as follows:

Food.	*Percentage of Calories lost through Non-absorption.*
Rice	2·6
Milk	4·4
Bread	4·5
Meat	5·5
Potatoes	6·8
Carrots	20·2

(Rubner.)

It will be observed that from this point of view rice and milk are much more economical foods than potatoes and meat.

Absorption of a Mixed Diet.

Most of the above experiments have necessarily been made when the subject of them was living upon a single article of diet only. But in ordinary life most people live upon a mixed diet, and it becomes necessary to inquire to what extent absorption goes on under these circumstances, and how the presence of one food in the intestine reacts upon the absorbability of another. In general terms it may be said that the constituents of a mixed diet are better absorbed than those of any one article of food when taken by itself. This comes out very clearly in some observations recorded in America.

An average of eleven experiments[1] on ordinary mixed diet gave the following results:

Constituents.	*Percentage absorbed.*
Organic matter	95·7
Proteid	92·6
Fat	94·4
Carbohydrate	97·1

In another experiment[2] the diet consisted of beef, eggs, bread and butter, milk, potatoes and fruit. The following were the percentages absorbed:

Proteid	94·9
Fat	96·9
Carbohydrate	98·9

In a third set of experiments[3] the subject lived upon beef, white and brown bread and butter, milk, oatmeal, potatoes and fruit, and absorbed of their constituents the following amounts:

Proteid	91·3 per cent
Fat	95·9 „
Carbohydrate	97·7 „

[1] Wait, United States Department of Agriculture, Bull. 53.
[2] Ninth Annual Report, Storrs Agricultural Experiment Station, p. 179.
[3] *Ibid.* A very complete summary of all the existing experiments upon the absorption of foods will be found in Bull. 45, United States Department of Agriculture, 1898.

The absorption of proteid would appear to be more favourably influenced by the presence of a mixture of foods than that of any other constituent. This is probably to be explained by the fact that the production of organic acids from the carbohydrates of a mixed diet exerts a restraining influence upon the destruction of proteids in the intestine by putrefactive bacteria.[1] Thus, it has been found by actual experiments that the constituents of bread and milk are better absorbed when these foods are taken together than when either is consumed alone.[2] The same was found by Rubner to hold good for a mixture of milk and cheese, as compared with either of these articles taken separately.

Taking the general results of all experiments, it has been calculated that the following proportions of nutritive constituents will be absorbed from a mixed diet[3]:

	Proteid.	*Fat.*	*Carbohydrates.*
Animal foods	98 per cent.	97 per cent.	100 per cent.
Cereals and sugars ..	85 ,,	90 ,,	98 ,,
Vegetables and fruits ..	80 ,,	90 ,,	95 ,,

It may be asked whether it is to be regarded as an advantage in a food that it is completely absorbed. The reply would be that a food which leaves a moderate amount of unabsorbed residue is certainly preferable. The intestine seems to require a certain amount of **ballast**—probably to act as a stimulus to its peristalsis. If herbivorous animals, such as rabbits, are fed upon a diet which leaves little or no residue, it has been found that they suffer from affections of the intestine which may even prove fatal, whereas such effects can be avoided by adding to the food any material which leaves behind an unabsorbed residue. Even in the case of man, who has a considerably shorter intestine, it is observed that a diet which is practically completely taken up into the blood, such as one composed exclusively of meat, is prone to be accompanied by intestinal disturbances. On the other hand, a diet which leaves behind a very large residue is not only wasteful in an economic sense, but demands for its manipulation and evacuation an undue amount of muscular and nervous energy on the part of the intestine. This, as we shall see later, is one of the drawbacks to a purely vegetable diet. In conditions of disease it may be necessary to take advantage of the behaviour of different foods in respect of absorption. If peristalsis is exaggerated, as in diarrhœa, one does

[1] The fatty acids liberated from neutral fats may perhaps act in a similar way.
[2] Bull. 53, United States Department of Agriculture, p. 44, 1898.
[3] Atwater, Storrs Agricultural Experiment Station, Ninth Annual Report, p. 187, 1896.

well to select those foods which are most completely absorbed, *e.g.*, rice, minced meat, or milk. In the opposite condition of diminished peristalsis and constipation, it is important to supply the intestine with a larger amount of 'ballast' than usual, and such foods as green vegetables and whole-meal bread most perfectly fulfil the requirements of the case.

Before leaving this subject two questions present themselves for consideration. The first is, may there not be individual differences in absorptive capacity? In other words, may some persons not extract the nutritive constituents from their food more thoroughly than others? It might be supposed that in this way some anomalies in dietetics would find an easy explanation, such, for example, as the unequal amounts of fat and flesh laid on by different individuals on the same diet. Tempting though this explanation is, it must be admitted that there are no exact observations in favour of it. On the contrary, it has been found that persons who have been accustomed, say, to a purely vegetable diet for years absorb its constituents no better than those to whom such a regimen is a comparative novelty (see p. 174). The large number of observations which have been made on different persons with the common articles of food have also failed to elicit any striking disparity in the degree to which absorption takes place, and even where the intestines are considerably deranged by disease there is a remarkable tendency for the ordinary degree of absorptive capacity to be maintained.

The second question which arises is this, Granted that the constituents of two foods are absorbed with equal completeness, may it not be true that the process of absorption demands a greater expenditure of energy in the one case than the other? Undoubtedly it is so; or, rather, the amount of energy which requires to be expended in order to reduce a food to a state in which absorption is possible may be greater in one case than in another. It has been found, for example, that for the same amount of proteid actually absorbed three to four times as much energy has to be expended in the case of bread as in that of milk. This is one of the advantages of a milk diet. Its absorption demands but little intestinal labour. That such labour is by no means inconsiderable is shown by the fact that, of the total amount of energy supplied to the body by a diet of bread and butter, fully 5 per cent. is expended merely in its digestion and absorption.[1]

[1] Pawlow, 'Die Arbeit der Verdauungsdrüsen,' p. 89.

It seems likely that in future more attention than hitherto will require to be paid to this aspect of digestion.

Reviewing the results yielded by the application of the physiological test to foods, it must be admitted that they are of great value. Had it always been carefully applied, certain common dietetic fallacies would never have gained the wide prevalence they at present enjoy. Examples of these are the supposed superiority of whole-meal to white bread (p. 210), and the erroneous notion that the fungi might, if properly taken advantage of, prove a cheap and valuable source of food. A more egregious instance is to be found in the idea that petroleum can act as a substitute for cod-liver oil. I have elsewhere[1] advanced experimental evidence to prove that petroleum cannot be absorbed by the human intestine. It is thus ruled entirely out of the class of true foods by the application of the physiological test, even if it were, as it is not, admissible to that class in virtue of its chemical properties.

Maly has aptly compared foods to ore, and their nutritive constituents to the metal which the ore contains. Just as metal has to be extracted from the ore before it is of any use, so, by the process of digestion, the nutritive constituents have to be extracted from a food before they can be absorbed. The chemical test tells us whether there is any metal present in the ore at all; the physiological test tells us whether or not the body is capable of extracting it.

4. **The Economic Test.**—Having ascertained the richness of a food in nutritive constituents, the amount of energy which it is capable of yielding, and the readiness with which it can be digested and absorbed, we have still to inquire whether the nutriment which it yields is obtained at a reasonable cost. For this we require an economic test. The simplest way of applying such a test is to find out how much energy (in Calories) and how much building material (in proteid) one can get for a particular sum when invested in the food under consideration. In the following diagram (Plate III.) the results of the application of this test to various typical articles of diet are set out. Looking first at the energy (Calories) obtained, one sees that bread leads the way, a shilling invested in bread yielding 10,764 Calories, or more than three times as much as is obtained for the same sum in milk, and more than ten times as much as can be got in the form of beef.

In the matter of *building material*, on the other hand, peas come first, a shilling's worth containing 572 grammes of proteid, or fully twice as much as can be obtained in cheese for the same expenditure. In

[1] *British Medical Journal*, March 25, 1899.

the form of eggs or beef building material is even more costly, the former being more than eight, and the latter more than five, times as expensive a source of proteid as peas.

Taking the results as a whole, it will be observed that the vegetable foods are far cheaper than the animal foods, whether one uses them as sources of energy or of building material. We shall see lat- that this is one of the strongest arguments in favour of vegetar

Of the various nutritive constituents of food, carbohydrate i the cheapest. The reason of this is that carbohydrates make chief bulk of most vegetable foods, and these are, as we ha seen, considerably cheaper than the foods of animal origin further question, why vegetable foods *are* cheap, will be con in another chapter (p. 176).

Compared with the carbohydrates, proteid and fat are v pensive constituents of foods, fat, perhaps, especially so. ' remarkable fact,' says Buckle,[1] 'and one to which I wou particular attention, that owing to some more general law, o we are ignorant, highly carbonized food is more costly than which comparatively little carbon is found.' The 'more gener of which he speaks is really the same law by which animal are dearer than vegetable. By far the larger part of the fat diet is derived from animal sources. The dearness of fat fortunate, and is not uncommonly a source of trouble in pr dietetics. One might mention, as an instance, the difficulty w diabetic, who has at the same time the misfortune to be a poo finds in providing himself with a diet suited to his disease. ne same remark applies, though less forcibly, to proteid.

The practical importance of having an economic test for foods is the more convincingly felt when one realizes that the market price of a food is no indication of its real money value. In the market one pays for flavour and rarity, not for nutritive qualities. It is the demands of the palate which cost, not those of the stomach, and we pay for æsthetic qualities in foods just as in dress we pay for 'cut' and ornament, not for material to keep us warm. Suppose, for example, that one wishes to buy a pound of fish. If sole is the form selected, it may cost 1s. 6d.; haddock would yield quite as much nutriment for 4d.; *i.e.*, in the former one is paying 4d. for nutriment, and 1s. 2d. for other qualities. Or take the case of arrowroot. A pound of the best Bermuda costs 2s. 9d., St. Vincent only 3d. or 4d. Yet both are, in a chemical sense, merely starch, and physiologically their behaviour is identical. It is the same with

[1] Buckle, 'History of Civilization,' vol. i., p. 62.

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EXPLANATION OF PLATE III.

In this diagram the Calories yielded by each food are shaded; the proteid is represented by the blue lines. The exact figures are as follow:

Food.		Calories Yielded.	Proteid Yielded (in Grammes).	Assumed Cost.
Bread	..	10,764	283	1¼d. per lb.
Peas	..	8,921	572	2d. "
Potatoes	..	3,796	54	½d. "
Milk	..	3,000	114	1½d. per pint.
Butter	..	2,884	3.5	1s. 3d. per lb.
Apples	..	2,856	27	1d. "
Cheese	..	2,638	272.5	6d. "
Fish	..	953	218	4d. "
Eggs	..	839	79	1s. 0d. per doz.
Beef	..	829	127	9d. per lb.

Fifteen per cent. of the weight has been deducted in the case of potatoes to allow of waste from peeling. It is assumed that the other foods are entirely edible. No allowance has been made for incomplete absorption.

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[1] Buckle, 'History of Civilization,' vol. i., p. 62.

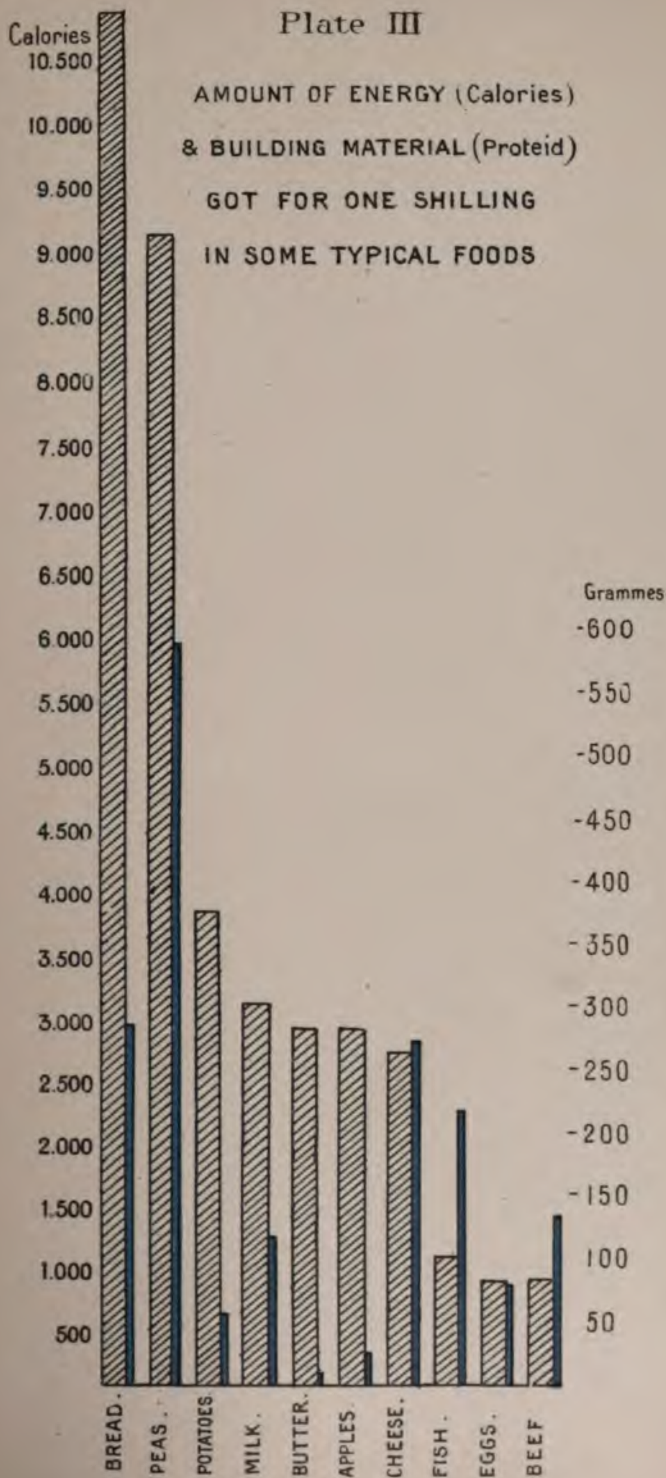


Plate III
AMOUNT OF ENERGY (Calories)
& BUILDING MATERIAL (Proteid)
GOT FOR ONE SHILLING
IN SOME TYPICAL FOODS
Calories
10.500
10.000
9.500
9.000
8.500
8.000
7.500
7.000
6.500
6.000
5.500
5.000
4.500
4.000
3.500
3.000
2.500
2.000
1.500
1.000
500
Grammes
-600
-550
-500
-450
-400
-350
-300
-250
-200
-150
100
50
BREAD.
PEAS.
POTATOES.
MILK.
BUTTER.
APPLES.
CHEESE.
FISH.
EGGS.
BEEF

cheese. A pound of Stilton costs 1s. 2d. The same amount of nutriment can be had in Dutch or American for 6d. These examples might be multiplied indefinitely, but they are sufficient to show that the maxim 'cheap and nasty' does not hold good for foods. I should be sorry to deny that æsthetic considerations should not be taken into account in selecting a dietary. It may be true that the sense of taste is as much worth cultivating as that of sight or hearing, but if one resolves to go in for luxury it is well to do so knowingly, and not imagine that one is nourishing the body when one is merely pleasing the palate.

To students and practitioners of medicine, a knowledge of the economic value of foods is of special importance. It is frequently our duty to see that the diet of a patient is enriched in special directions, most commonly, perhaps, in that of proteid or fat. There is no use in recommending to a poor man chicken and cream. He simply can't afford to buy them. It is worth while to remember, however, that the cheapest sources of building material are *skim* milk, some form of fish (*e.g.*, herring or salt fish), cheese, the cheaper cuts of meat, and, if his digestion be good, the pulses, while the most economical forms of fat are margarine and dripping. These articles are within the reach of almost everybody.

To the poorer classes, too, such knowledge is of special value. It must be remembered that, of the wages which a working man receives, fully 50 per cent. *must* be spent on food alone,[1] and that the poorer a man is the larger is his proportionate expenditure on this item. And yet the pathetic thing is that it is just this class of the community whose food purchases are apt to be the most irrational. Surely there is here room for popular instruction.

Of two other points which concern the economy of foods no mention has been made; I refer to 'waste' and the cost of cooking. Of avoidable waste there is no need to speak, though in this country at least we have much to learn in that respect from some of our Continental neighbours. By *unavoidable* waste one means that a considerable proportion of much food as purchased is not in an edible form; I refer to such things as the skin and skeleton of fish, the bone of meat, and some parts of green vegetables. In ordinary cuts of meat the unavoidable waste may be reckoned as about 15 per cent.; in fish it may sometimes rise as high as 70 per cent. This must certainly be taken into account in making purchases of food. In the

[1] See 'Family Budgets' (London: P. and S. King), 1896, and Oliver, 'The Diet of Toil, and its Relation to Wages and Production,' a paper read at the Congress of Hygiene and Demography, Buda-Pesth, September, 1894.

diagram (Plate III.) allowance has been made for these waste matters, but no account has been taken of the cost of cookery. This is a matter which it is exceedingly difficult to estimate, as so much depends upon the cook, but the general value of the results is not seriously impaired by the omission.

In conclusion, I would point out what the reader has no doubt already perceived for himself, that it is by no means an easy matter to pronounce an opinion upon the value of a food offhand. Each test must be applied in turn, and it is only upon those foods which come satisfactorily out of all of them that a favourable verdict can be pronounced all round; in other words, that is only to be adjudged a 'good' food which contains an ample proportion of nutritive constituents, which is easily digested and absorbed, and which can be obtained at a reasonable cost.

CHAPTER II

THE AMOUNT OF FOOD REQUIRED IN HEALTH

THE amount of food required to meet the daily needs of the body may be represented in three different ways:

1. In terms of potential energy, *i.e.*, Calories.
2. In terms of the most important chemical elements which it contains, *i.e.*, nitrogen and carbon.
3. In terms of the nutritive constituents, *i.e.*, proteid, carbohydrate, and fat.

The results, when translated into quantities of ordinary foodstuffs, form the basis of '**standard**' **dietaries.**

The data necessary for the construction of such dietaries may be obtained in different ways. There is, firstly, what one may call the purely *physiological method.* A man is shut up in a respiration calorimeter. All the heat which he gives out from his body in a given time is measured, and the work which he does is also measured and expressed in terms of heat. The quantity of carbon and nitrogen given off is ascertained by analysis of the expired air and the excreta. In this way one learns (1) the total amount of potential energy which must be supplied in the food in order to cover the actual energy produced in the form of heat and work, and (2) the amount of carbon and nitrogen which must be provided in order to meet the outgoings of these from the body; in other words, one ascertains how much food must be supplied in order to provide for the conservation of energy and the conservation of matter in the body.

Not many experiments of this sort have been made with men. A few have recently been carried out in America,[1] and doubtless this method will be largely employed in future investigations.

By far the larger number of observations have been made by what one may call the **empirical method.** A healthy individual living

[1] 'Description of a New Respiration Calorimeter,' Bull. 63, United States Department of Agriculture, 1899.

under known conditions and on a freely-chosen diet is selected, the food which he eats and the excreta given off from his body are analysed, and in this way one discovers whether or not the income in diet is equal to the expenditure as represented by the waste products excreted. The method may be modified by varying the diet in different directions, and seeing how each change affects the balance-sheet of the body, or groups of persons living under similar conditions may be chosen instead of individuals, and the average amount of food required calculated from the total consumed by the group. Such observations have mostly been made on the inmates of public institutions.

The empirical method has been employed by Playfair in this country, very notably by Voit and his followers of the Munich School in Germany, by Moleschott and others in Italy, more recently by various observers in Russia and Japan, and to a very large extent by Atwater and his associates in America. Altogether a large mass of information has been collected, the practical outcome of which we may now proceed to consider.

1. **As regards potential energy**, the results show that a healthy man of about 11 stones weight, and doing a moderate amount of muscular work, must be supplied with from 3,000 to 3,500 Calories if his daily needs are to be fully covered. This is the *physical* standard of the amount of food required, and just as in judging of the relative values of different foods, so here it is the only absolute standard which is universally applicable. However much the constituents of the diet may vary, of this there is no doubt, that, taken together, the sum of the potential energy which they yield must be about 3,500 Calories.

2. Concerning **nitrogen and carbon**, it is found that such a man as the above excretes in round numbers about 20 grammes of the former and 320 of the latter every day, both of which amounts must, therefore, be fully represented in the food.

3. If one asks, lastly, how much of each nutritive constituent is required, the reply is by no means so easy. Let us consider the case of *proteid* first.

How much Proteid is required Daily?[1]

It has been stated above that an ordinary man, on a freely-selected diet, excretes about 20 grammes of nitrogen daily. It may be

[1] For a full discussion of this question, see Hirschfeld, 'Ueber die Grundsätze der Ernährung' (*Berlin. Klin. Woch.*, No. 26, 1891); Demuth, 'Ueber die bei der Ernährung des Menschen nöthige Eiweissmenge' (*Münch. Med. Woch.*, Nos 42-44, 1892); and Munk in Weyl's 'Handbuch der Hygiene,' iii., pp. 85, 86, 1896.

assumed that all of this should be supplied in the form of proteid, and as proteid contains about 16 per cent. of nitrogen, it is obvious that 125 grammes of the former will be able to supply 20 grammes of the latter. As a matter of fact, that is the generally accepted standard for the amount of proteid required daily, but it is by no means an absolute one. The reason of this is that the body is able to establish an equilibrium on very various quantities of proteid. The typical man referred to above excretes 20 grammes of nitrogen daily, merely because he consumes that amount in his daily food. Had he consumed 15 grammes, he would only have excreted 15 grammes, and if his consumption had risen to 25 or 30 grammes or higher, his excretion would still have kept pace with it. It is this tendency for the amount of nitrogen excreted to be exactly equal to the amount consumed which physiologists call the establishment of **nitrogenous equilibrium**, and it is evident that such equilibrium can be established on very various quantities of proteid. The question, therefore, is, What quantity is best? To this, it may be at once confessed, no absolute reply can be given. When one recollects that the chief function of proteid is to keep in repair the tissues of the body, one is tempted to suppose that all that is necessary is to consume enough for that purpose. Anything above that, it might be thought, would be mere extravagance—the *luxus consumption* of the older school of physiologists. But how to ascertain that bare amount? The reply at once suggests itself that in the amount of nitrogen excreted during starvation there will be found a measure of the amount which just suffices to keep the tissues in repair. Now, a man who has been starving for some time excretes about 4 to 5 grammes of nitrogen daily,[1] but as a matter of fact it is found that if merely this amount is supplied in the food it is *not* sufficient to establish equilibrium. Indeed, the smallest amount of nitrogen on which it is possible to establish equilibrium is found to be from three to four times the amount excreted during hunger. Should we, then, attempt to live on this minimum? Now, that is a very difficult question. Remembering that, although the chief use of proteid is to build up and repair the tissues, yet every gramme of it is also capable of supplying to the body 4·1 Calories of energy (p. 5), it is evident that the problem which confronts us can be stated in another way. Should we make use of proteid *merely as building material*, relying upon carbohydrate and fat as our sources of

[1] For observations on fasting men, see 'A Digest of Metabolism Experiments,' United States Department of Agriculture, Bull. 45 (revised edition), p. 87, 1898.

energy, or should we also take advantage of its capability of providing for heat and work?

Before finally replying to this question another factor in the problem must be presented. We know from physiological experiment that the greater the quantity of carbohydrate and fat which is supplied along with proteid, the less does the latter tend to be wasted in supplying energy, and the more of it there is available for the higher purpose of keeping the tissues in repair. The fat and carbohydrate are sacrificed instead of the proteid. This is what physiologists mean when they describe fats and carbohydrates as **proteid sparers.** But it is almost impossible so to arrange matters that *all* the energy shall come from fat and carbohydrate, and so leave all the proteid free for repairing the fabric of the body. And for this reason: the cells of the body may be supposed to be bathed with lymph containing in solution particles of proteid, fat, and carbohydrate derived from the blood. These particles are attacked by the cells and oxidized, heat and energy being liberated in the process. But the cells do not seem to be able to attack each of these constituents with equal ease. Of the three constituents mentioned, proteid is most easily broken down, then carbohydrate, fat least easily of all. If, then, the three are present in equal proportion, there will always be more of the proteid attacked than of the others. But if, on the other hand, carbohydrate and fat are present in great excess, they assert themselves by their mere 'mass influence,' and exclude many of the proteid particles from ever coming into contact with the cell at all—crowding them out, so to speak—and so sparing the proteid from destruction. It is almost impossible, however, to get the three chief nutritive constituents into the neighbourhood of the cell in such proportions that *none* of the easily-attacked proteid is used up. By giving abundance of carbohydrate this object can be more easily effected than by fat, for, as we have seen, the cells have less difficulty in coping with the former than the latter. Gelatin is an even more efficient sparer of proteid (see p. 76). Hence it is that those foods which contain a very large excess of carbohydrate along with a moderate proportion of proteid, and in which both are absorbed and reach the cells at about the same rate—a most important point—will be the foods on which least proteid is likely to be wasted and the largest fraction of it reserved for tissue repair. In other words, these will be the foods to have recourse to if one wishes to preserve nitrogenous equilibrium on a minimum amount of proteid. In accordance with this, it h[illegible] been found that nitrogenous equilibrium can be maintained on [illegible]

to 1,600 grammes of bread containing only 104 grammes of proteid, on 800 grammes of maize with 74 of proteid, and on 3,080 grammes of potatoes in which the total proteid amounts to not more than 54 grammes; and yet all of these quantities are sufficient to supply 3,000 Calories daily (Rubner).

But now the further question arises: granted that it were possible to restrict the supply of proteid in the diet to the bare amount required to keep the tissues in repair and to get all our energy from fat and carbohydrates, is such a course advisable on other grounds? This, as we shall see later, is one of the problems at the root of vegetarianism, and we shall return to it when discussing that subject (p. 167); but I would remark here that such an arrangement is probably *not* advisable. It is well to have an excess of proteid above that barely required for tissue repair. To live on a minimum of proteid is to run the risk of having what one may call 'threadbare tissues,' and of having no reserve for use in emergencies. And such a condition of things makes for low resistance and for disease. There is also reason to believe that proteid, besides acting as a repairer of tissue and a source of energy, exerts upon the cells a stimulating influence which increases vitality and energy (see also p. 169). A deficiency of it, too, seems to impair the condition of the blood and lower the tone of the muscles and of the heart, besides enfeebling the digestive powers by restricting the supply of the material from which the digestive ferments are elaborated.

The reply, then, to the question: should one use proteid merely to repair tissues? would be in the negative. It is clearly advisable to make use of *some* proteid as a source of energy also. Reverting, however, to the original problem from which we set out—how much proteid the diet ought to contain—it will be evident from the above discussion that no absolute and invariable amount can be fixed. It depends so much on the quantity of the other constituents, *i.e.*, proteid sparers, consumed at the same time. In the last resort, therefore, we are driven for guidance to the results yielded by actual analysis of the diets selected by healthy persons. The value of such results must not be underestimated. Men have found out by long experience what is the best diet, better, perhaps, than science can tell them. Examination of such diets reveals the fact that the amount of proteid consumed is, as we have already seen, about 125 grammes daily. Such an amount of proteid would be contained in twenty eggs, or in four and a half ordinary platefuls of cooked meat (18 ounces). It must be admitted that many persons manage to maintain an apparently healthy life on a much smaller daily

supply of proteid than this, the amount consumed sinking in some cases to less than 50 grammes daily. It will be found, however, that most of these instances occur in persons of small body-weight, many of them being Asiatics, who consume in their food a relatively enormous quantity of carbohydrates. For ordinary individuals such a small proteid supply must be regarded as risky, and the daily consumption should never be allowed to sink below 100 grammes, but should preferably be 125.

How much Carbohydrate and Fat should the Diet contain?

We may consider these two constituents together, representing as they do the chief sources from which the carbon required by the body must be obtained. It was shown that about 300 to 320 grammes of carbon are required daily to replace the loss in the excreta. Proteid contains about half its weight of carbon, so that 125 grammes of the former will provide 62 of the latter, leaving at least 240 grammes to be supplied in the form of carbohydrate and fat. We have now to ask what proportion of this amount should be supplied as fat and carbohydrate respectively? As far as the demand of the cells for energy is concerned, this is probably a matter of indifference, provided one remembers always that it takes 2¼ parts of carbohydrate to supply as many Calories as 1 part of fat. To the digestive organs, however, it is by no means a matter of indifference. If *all* the carbon not provided as proteid were to be supplied in the form of carbohydrate, it would mean that a large *bulk* of food must be consumed, which would be not only apt to overload the stomach and intestines by its mere weight, but would also be prone to undergo fermentation, leading to the production of flatulence and acidity. If, on the other hand, fat be adopted as the exclusive source, one would run the risk of overstepping the limits of fat absorption, and nausea, and probably diarrhœa, would ensue. In this matter habit and personal peculiarity have a great influence. There are some races, such as the Esquimaux, who take almost the whole of their carbon in the form of fat; others, such as the Hindoos, take it mainly in the form of carbohydrates. The Scotchman is notoriously less inclined to eat fat than the Englishman, and one constantly meets with individuals who have an insuperable repugnance to the consumption of even moderate amounts of fat. We have already seen that 150 grammes of fat can be absorbed daily without much difficulty, but in most persons anything above 100 grammes (3½ ounces) in winter, and rather less in summer, would be apt to

produce disorders of digestion. For this reason alone, therefore, it is well to take a mixture of carbohydrate and fat rather than either of these exclusively, and 50 grammes of fat (= 2½ ounces of butter) to 500 of carbohydrate (= 1 pound 2 ounces of sugar) may be regarded as a reasonable proportion. This is in the proportion of 1 part of fat to 10 of carbohydrate. Many authorities, however, recommend more of the former and less of the latter.

Some direct observations on this point were made by Forster[1] on the actual dietaries of different individuals. He found that to every part of fat the following amounts of carbohydrate were consumed:

Subject.	*Carbohydrate.*
Infant	1·4
Child of five months	1·4
Labourer's child	5·6
Well-to-do adult	3·4
Labourer	5·0
Old man	5·1
Old woman	5·3
Nursing woman	2·4

The results show that in every case investigated the quantity of fat obtainable was considerably greater than the amount fixed in the standard.

The question of expense also comes in here. Fat is a dear but compact form of carbon; carbohydrate is bulky but cheap. Those who can afford it tend to get the advantages of a condensed food, in spite of its greater cost; while those to whom pecuniary considerations are of importance must put up with the inconveniences of the more bulky food in exchange for its greater cheapness.

Hence one finds that, as a matter of observation, the food of the rich is usually much more fatty than that of the poor.

Opportunity, also, is a determining factor. The Esquimaux eats much fat because he cannot grow crops; the Hindoo consumes much carbohydrate because he has not got facilities for grazing cattle.

Here, as in so many other cases, necessity determines the choice, and custom makes it the most agreeable.

Notwithstanding the above considerations, to which the practical solution of the question must usually be left, it is still of some scientific interest to ask whether there may not be some part played in the body by fat which is not so well fulfilled by carbohydrates, and *vice versâ*. There is not much in the way of experimental evidence to help us in coming to a conclusion on this point, but there is a prevailing belief among competent observers that in the diet of children, at least, a deficiency of fat cannot be replaced by an

[1] Pettenkofer and Ziemssen's 'Handbuch der Hygiene,' Bd. I., p. 137.

excess of carbohydrate, and that fat seems to play some part in the formation of young tissues which cannot be undertaken by any other nutritive constituent of food.[1] The association of rickets, especially, with a deficiency of fat in the diet seems to be pretty firmly established. An attempt has recently been made[2] to put this belief to the test of exact experiment by feeding young pigs on milk from which almost the whole of the fat has been removed by a separator. It was found, however, that the animals so fed did not become rickety, nor did the fatty matter which is so abundantly present in the central nervous system undergo any diminution. On the other hand, the subcutaneous fat almost entirely disappeared, and was replaced by a gelatinous sort of connective tissue. The curious fact was also observed, that the deficiency of fat in the food led to an interference with the absorption of phosphorus, although no explanation of this is advanced. If a large excess of carbohydrate was supplied, it was found that the subcutaneous fat did not undergo such marked diminution. It must be admitted that the belief that fat is necessary for the formation of new tissues receives but little confirmation from this experiment.

One point in which fat is not able to replace carbohydrate in its dynamic equivalent is in proteid-sparing power. In this direction 1 part of fat is *not* as efficient as 2¼ parts of carbohydrate.[3] If, therefore, the proportion of fat in the diet be increased, the amount of proteid consumed must also be increased. An examination of freely-chosen diets shows that this is actually done.

One may sum up the **standard amounts of the different nutritive constituents required daily** thus:

Proteid	125 grammes.
Carbohydrate	500 ,,
Fat	50 ,,

These would yield the following amount of energy in Calories:

Proteid	$125 \times 4.1 = 512.5$
Carbohydrate	$500 \times 4.1 = 2050$
Fat	$50 \times 9.3 = 465$
Total	$= 3027.5$ Calories.

[1] See, for example, Cheadle, 'Artificial Feeding and Food Disorders of Infants' (London: Smith, Elder and Co.), p. 12.

[2] *Journal of Experimental Medicine*, iii. 293, 1898.

[3] See Von Noorden, 'Pathologie des Stoffwechsels,' p. 117. Wicke and Weiske (*Zeits. f. physiol. Chemie*, xxi. 42, 1895, and xxii. 137, 1896), found that 100 grammes of starch diminished proteid katabolism 19 to 21 per cent.; a similar weight of fat diminished it by 30 to 40 per cent.; *i.e.*, the absolute effect of fat is greater than that of carbohydrate, but the relative effect is less.

Or, in terms of carbon and nitrogen :

125 grammes proteid	..	= 20 grammes N and	62 grammes C.
500 ,, carbohydrate		=	200 ,,
50 ,, fat ..	..	=	38 ,,
Total	..	= 20 grammes N and	300 grammes C.

Such a standard may be regarded as the minimum for a man of average build and weight, and doing a moderate amount of muscular work.

In the following table I have collected similar standards fixed by other workers:

Authority.	Proteid.	Fat.	Carbohydrate.	Calories.
Munk	105	56	500	3,022
Wolff	125	35	540	3,030
Voit	118	56	500	3,055
Rubner	127	52	509	3,092
Playfair	119	51	531	3,140
Moleschott	130	40	550	3,160
Atwater	125	125	450	3,520
Average	121	59	510	3,135

It will be observed that the chief point of divergence is in the relative proportion of carbohydrate and fat allowed; the amount of proteid is very similar in all. The total Calories yielded is remarkably constant, despite these divergences. It should also be stated as regards that point that no account is taken in these standards of the inevitable loss which results from incomplete absorption of the constituents. To allow for this, the total Calories yielded would require to be reduced in each case by about 200.

In such standards the ratio of proteid to carbohydrates and fat taken together is of some importance. It is called the **nutritive ratio.** If 1 part of fat be counted as $2\frac{1}{4}$ parts of carbohydrate, the nutritive ratio in the average of the above standards is as 1 to 5·3. In this ratio we have an index of the proportion which the building material of the diet ought to bear to its purely energy-yielding constituents.

It need hardly be remarked that we do not consume our food in the form of pure proteid, carbohydrate, and fat. If, therefore, the above conclusions are to be of any practical value, they must be translated into terms of ordinary articles of diet.

Necessity for a Mixed Diet.

In the first place it may be remarked that no one article of food contains the different nutritive constituents in proper propor-

tions. This can be most clearly brought out by examining the relative proportions in which carbon and nitrogen are contained in some ordinary foods. Assuming, again, that 20 grammes of nitrogen and 320 of carbon are required daily, this gives a relative proportion of 1 of the former to every 16 of the latter. Now, the proportion in some typical articles of diet is actually as follows:

Food.	*Nitrogen.*		*Carbon.*
White fish	1	to	4
Roast beef	1	to	5
Eggs	1	to	7
Cheese	1	to	10
Milk	1	to	11
Dried peas	1	to	12
Bread	1	to	28
Potatoes	1	to	33

It will be observed that some foods are too rich in nitrogen; others contain too much carbon. The former statement is true of all animal foods, and, amongst the vegetable foods, of such articles as dried peas, beans, and lentils. Most other vegetable foods, on the contrary, of which bread and potatoes may be taken as types, contain an excess of carbon.

The practical outcome of this is that a proper diet must be a mixed diet, the excess of a particular element in one article being played off against its deficiency in another. People have found this out for themselves by experience; hence the popularity of such combinations as bread and cheese, bacon and beans, or potatoes and beef, in which the surplus of carbon in the first article is made up for by the excess of nitrogen in the second. In a similar way we strike a proper balance in puddings by compounding them of articles rich in nitrogen on the one hand, such as eggs and milk, with articles containing a surplus of carbon on the other, such as rice or bread. The use of white sauce with fish is an example of a similar adaptation.

That mankind are right in so doing is borne out by the disastrous results which have followed attempts to live for any length of time on a single article of diet.

Hammond[1] tried to live on a daily ration of a pound and a half of starch, along with water. He had to abandon the experiment on the tenth day, owing to the onset of debility and fever. On another occasion he attempted to live on nothing but albumin. After nine days diarrhœa and albuminuria supervened, and the experiment had to be given up.

[1] 'Transactions of the American Medical Association, 1857,' p. 511. For similar experiments see Flint's 'Physiology of Man,' p. 128.

Dr. Salisbury[1] experimented on himself and some other healthy persons with an exclusive diet of porridge. He found that such a regimen resulted in flatulence, acidity, and diarrhœa, and had to be discontinued. Baked beans, when eaten alone, produced similar disagreeable effects.

In the case of Dr. William Stark, a young English physician of last century, the results were more tragical. He lived for forty-four days on bread and water, for a month on bread, water, and sugar, and for three weeks on bread, water, and olive-oil. At the end of his experiments he had fallen into a very feeble state of health; he developed symptoms resembling scurvy, and ultimately died, apparently a victim of his own scientific enthusiasm.[2]

Standard Dietaries.

A good standard diet, adapted to English habits, and suitable for a man doing a moderate amount of muscular work, is given by Waller, and is thus constituted:

		Carbon.	*Nitrogen.*
Foundation:	1 lb. bread	117	5·5
	½ lb. meat	34	7·5
	¼ lb. fat	84	
Accessories:	1 lb. potatoes ..	45	1·3
	½ pint milk.. ..	20	1·7
	¼ lb. eggs	15	2·0
	⅛ lb. cheese ..	20	3·0
	Total	335 grammes.	21·0 grammes.

In order to realize more clearly what a diet like this means, its constituents may be divided up into meals, which would work out as follows:[3]

Breakfast ..	Two slices of bread and butter. Two eggs.
Dinner ..	One plateful of potato soup. A large helping of meat with some fat. Four moderate-sized potatoes. One slice of bread and butter.
Tea	A glass of milk and two slices of bread and butter.
Supper ..	Two slices of bread and butter and 2 ounces of cheese.

This is a rather liberal diet, and its raw ingredients cost a little more than a shilling.

[1] 'Alimentation and Disease' (New York, 1895).

[2] See 'The Works of the late William Stark, M.D.,' London, 1788, which includes a biographical notice.

[3] The amount of each raw article consumed at the different meals is calculated from the following data: A slice of bread 5 inches long, 3½ broad, and ¾ inch thick weighs 2½ ounces. An ordinary plateful of meat without bone represents 5 ounces of raw or 4 ounces of cooked meat. Six medium-sized potatoes = 1 lb. It is assumed that one egg = 2 ounces. A plateful of potato soup contains two potatoes. An ounce of butter will cover three or four slices of bread.

The following table represents, with some modifications, similar standard daily dietaries constructed by Atwater:

STANDARD DIETARIES.

Daily Dietaries.—Food materials furnishing approximately the 0·28 pound (= 125 grammes) of proteid and 3,500 Calories of energy of the standard for daily dietary of a man at moderate muscular work.

Food Materials.	Amount.	Cost.	Nutritive Constituents.				Fuel value.
			Total Organic Matter.	Proteid.	Fats.	Carbo-hydrates.	
I.	*Ounces.*	*s. d.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
Beef, round steak ..	13	0 6	·26	·14	·12	—	695
Butter	3	0 3	·16	—	·16	—	680
Potatoes	6	0 0½	·17	·02	—	·15	320
Bread	22	0 2½	·89	·12	·02	·75	1,760
	44	1 0	1·48	·28	·30	·90	3,455
II.							
Pork, salt	4	0 1½	·21	—	·21	—	880
Butter	2	0 2	·11	—	·11	—	450
Beans	16	0 2½	·84	·23	·02	·59	1,615
Bread	8	0 1	·33	·04	·01	·28	640
	30	0 7	1·49	·27	·35	·87	3,585
III.							
Beef, neck	10	0 2½	·19	·10	·09	—	550
Butter	1	0 1	·05	—	·05	—	225
Milk, 1 pint	16	0 2	·13	·04	·04	·05	325
Potatoes	16	0 1	·17	·02	—	·15	320
Oatmeal	4	0 1	·23	·04	·02	17	460
Bread	16	0 2	·67	·09	·02	·56	1,280
Sugar	3	0 0½	·19	—	—	·19	345
	66	0 10	1·63	·29	·22	1·12	3,505
IV.							
Beef, upper shoulder	10	0 3½	·22	·09	·13	—	800
Ham	6	0 3	·19	·06	·13	—	650
Two eggs	3	0 2	·05	·03	·02	—	135
Butter	2	0 2	·11	—	·11	—	450
Milk, 1 pint	16	0 2	·13	·04	·04	·05	325
Potatoes	12	0 0¾	·12	·01	—	·11	240
Flour	9	0 0¾	·44	·05	·01	·38	825
Sugar	1	0 0¼	·06	—	—	·06	115
	59	1 2¼	1·32	·28	·44	·60	3,540
V.							
Sausage	4	0 1½	·14	·03	·11	—	510
Cod-fish	14	0 3½	·07	·07	—	—	140
Butter	2	0 2	·11	—	·11	—	450
Milk, 1 pint	16	0 2	·13	·04	·04	·05	325
Beans	5	0 0¾	·26	·07	·01	·18	505
Rice	2	0 0½	·11	·01	—	10	205
Potatoes	16	0 1	·24	·01	—	·23	420
Bread	9	0 1	·33	·04	·01	·28	640
Sugar	3	0 0½	·19	—	—	·19	345
	71	1 0¾	1·58	·27	·28	1·03	3,540
VI.							
Beef	8	0 3	·18	·08	·10	—	560
Mackerel, salt ..	4	0 1½	·08	·04	·04	—	230
Two eggs	3	0 2	·05	·03	·02	—	135
Butter	2½	0 2½	·13	—	·13	—	565
Cheese	1	0 0½	·04	·02	·02	—	130
Milk, 1 pint	16	0 2	·13	·04	·04	·05	325
Potatoes	8	0 0½	·09	·01	—	·08	160
Rice	2	0 0½	·11	·01	—	·10	205
Bread	9	0 1	·38	·05	·01	·32	720
Sugar	1½	0 0¼	·69	—	—	·09	175
	55	1 1¾	1·88	·28	·36	·64	3,205

It is worth while noticing, incidentally, the relative cost of these diets. Compare, for example, in this respect, No. II. with No. IV. Both of these contain practically the same amount of nutriment, but the latter costs exactly twice as much as the former. This is a fresh proof of the fact which has already been insisted upon, that the cost of a diet is no indication of its nutritive value.

The total weight of *dry* food which is consumed daily in such a standard diet as any of the above is about 23 ounces (or almost 1 ounce per hour). This represents 45 ounces (nearly 3 pounds) of ordinary food.

Actual Dietaries.

The standard dietaries given above are constructed, as we have seen, from theoretical data. It is interesting to compare with them the composition of the ordinary diets actually consumed by individuals of different countries and different social rank. In the following table (also modified from Atwater)[1] a large number of such dietaries have been collected :

ACTUAL DIETARIES.

Classes.	Nutritive Constituents.				Potential Energy.
	Proteid.	Fats.	Carbo-hydrates.	Total.	
European and Japanese Dietaries.	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Calories.*
1. Sewing-girl, London, wages 3s. 9d. per week	53	33	316	402	1,820
2. Factory girl, Leipsic, Germany, wages 5s. per week	52	53	301	406	1,940
3. Weaver, England, time of scarcity	60	28	398	486	2,138
4. Labourers, Lombardy, Italy; diet mostly vegetable	82	40	362	484	2,192
5. Trappist monk in cloister; very little exercise, vegetable diet	68	11	469	548	2,304
6. Students, Japan	97	16	438	551	2,343
7. University professor, Munich, Germany; very little exercise	100	100	240	440	2,324
8. Lawyer, Munich	80	125	222	427	2,401
9. Physician, Munich	131	95	327	553	2,762
10. Painter, Leipsic, Germany	87	69	366	522	2,500
11. Cabinet-maker, Leipsic, Germany	77	57	466	600	2,757
12. 'Fully-fed' tailors, England	131	39	525	695	3,053
13. 'Well-paid' mechanic, Munich, Germany ..	151	54	479	684	3,085
14. Carpenter, Munich, Germany	131	68	494	693	3,194
15. 'Hard-worked' weaver, England	151	43	622	816	3,569
16. Blacksmith, England	176	71	667	914	4,117
17. Miners at very severe work, Germany ..	133	113	634	880	4,195
18. Brick-makers (Italians at contract work), Munich	167	117	675	959	4,641
19. Brewery labourer, Munich; very severe work, exceptional diet	223	113	909	1,245	5,692
20. German soldiers, peace footing	114	39	480	633	2,798
21. German soldiers, war footing	134	58	489	681	3,093
22. German soldiers, Franco-German War; extra-ordinary ration	157	285	331	773	4,652
23. Russian workmen	132	80	583	—	3,675
24. Swedish workmen (moderate labour)	134	79	523	—	3,436
25. Swedish workmen (hard labour)	189	110	714	—	4,726

[1] Report of United States Commissioner of Fish and Fisheries, 1888.

ACTUAL DIETARIES—*continued.*

Classes.	Nutritive Constituents.				Potential Energy.
	Proteid.	Fats.	Carbo-hydrates.	Total.	
United States and Canadian Dietaries.	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Calories.*
26. French Canadians, working people, in Canada	109	109	527	745	3,622
27. French Canadians, factory operatives, mechanics, etc., in Massachusetts	118	204	549	871	4,632
28. Other factory operatives, mechanics, etc., Massachusetts	127	186	531	844	4,428
29. Glass-blowers, East Cambridge, Mass. ..	95	132	481	708	3,590
30. Factory operatives, dressmakers, clerks, etc., boarding-house	114	150	522	786	4,002
31*a*. Well-to-do private family, Connecticut .. ... food purchased	129	183	467	779	4,146
31*b*. Well-to-do private family, Connecticut .. ... food eaten	128	177	466	771	4,082
32*a*. College students from Northern and Eastern States; boarding-club, 2 dietaries of the same club — food purchased	161	204	680	1,045	5,345
32*b*. — food eaten	138	184	622	944	4,827
33*a*. — food purchased	115	163	460	738	3,874
33*b*. — food eaten	104	136	421	661	3,417
34. College football team, food eaten	181	292	557	1,030	5,742
35. Machinist, Boston, Mass.	182	254	617	1,053	5,638
36. Brick-makers, Middletown, Conn.	222	263	758	1,243	6,464
37. Teamsters, marble-workers, etc., with hard work; Boston, Mass.	254	363	826	1,443	7,804
38. Brick-makers, Cambridge, Mass.	180	365	1,150	1,695	8,848
39. U.S. Army ration	120	161	454	735	3,851
40. U.S. Navy ration	143	184	520	847	4,998
41. Average of 53 American studies for different classes	103	138	436	677	3,500

On examining the table, it will be observed that, on the whole, the results conform very closely to the ideal standard already laid down. Here and there, however, one meets with divergences. Thus, the diet of the sewing-girl in London (which was investigated by Playfair) must be regarded as insufficient for the needs of health, while that of the well-to-do family in Connecticut (No. 31) is needlessly liberal. Taking the results as a whole, however, one is astonished at the closeness with which the actual corresponds to the ideal.

Application of these Standards.

It must be clearly realized that such standard dietaries as those we have been considering have only a limited range of usefulness. They cannot be rigidly applied in any particular case, for they have only been drawn up to meet the needs of typical individuals living under known conditions, and doing a moderate amount of muscular work. They are of great value, however, in helping us to draw up rations for persons who have no free choice in their diet, and who are living under fairly uniform conditions (*e.g.*, soldiers and the

inmates of prisons, workhouses, etc.), and as furnishing us with a standard by which to gauge the probable sufficiency or otherwise of the dietary which choice or necessity has imposed upon any section of the community. Some examples of the way in which they have actually been applied for such a purpose may serve to make the matter clearer.

Omitting the well-known investigations of Playfair,[1] one of the earliest examples of the application of dietary standards in economic investigations is to be found in two papers by my father,[2] contrasting the relative nutritive values of the diet of English and Scottish agricultural labourers in the year 1867. I mention these papers here because the results which they contain, although of considerable interest and value, have been to a large extent ignored by later workers in the same field. The diet of upwards of a hundred families drawn from all parts of England and Scotland was investigated, the nutritive value of each being represented in terms of nitrogen and carbon. The average results may be represented as follows:

	Average Scotch Adult.	Average English Adult.
Carbon	410 grammes daily	330 grammes daily
Nitrogen	18 " "	12 " "

Bearing in mind the standard already laid down, it will be observed that in both cases there is a deficiency of nitrogen and an excess of carbon as compared with the ideal quantities. The greater nutritive value of the Scotch diet was found to be due to the fact that it consisted very largely of oatmeal and milk, while both of these articles were but scantily represented in the dietary of the English labourer.

More recent and perhaps more accurate, but less extensive, investigations of a similar sort have been made by Professor Oliver.[3] The following examples are selected from the fifteen actual dietaries which he investigated. Comparing typical representatives of the agricultural population of England, Scotland, and Ireland, he found the following amounts of carbon and nitrogen in the diet:

---

1 'On the Food of Man in Relation to his Useful Work,' Edinburgh, 1865.
2 'On the Dietaries of Scotch Agricultural Labourers,' and 'On the Economic Condition of the English Agricultural Labourer,' etc., by Robert Hutchison, F.R.S.E.; Transactions of the Highland and Agricultural Society of Scotland, 1867 and 1871.
3 'The Diet of Toil,' 1895.

1. *Northumbrian Hind.*

	C.	N.
Breakfast (5 a.m.)—		
Porridge (½ meal)	50	2·2
Milk	20	1·7
2nd Breakfast (8 a.m.)—		
Tea	12	
Bread (2 slices = ¼ lb.)	29·2	1·3
¼ oz. butter	6·6	
Dinner—		
6 oz. potatoes	16·5	·5
6 oz. bacon	123	6
Tea—		
Tea	12	
Bread	29·2	1·3
¼ oz. butter	6·6	
Supper—		
Bread and Milk	24·6	·8
	329·7	8·4

2. *Ayrshire Ploughman.*

	C.	N.
Breakfast—		
Porridge	99·6	4·4
Milk	20	1·7
¼ lb. oatmeal, ½ pint milk		
Dinner—		
Broth	? 10	·6
¼ lb. meat	34	7·5
¾ lb. potatoes	33·7	·9
Tea—		
Porridge	99·6	4·4
½ pint milk	20	1·7
½ pint tea	6	
4 oz. bread	29·2	1·3
¼ oz. butter	10	
	362·1	22·5

3. *Irish Peasant.*

	C.	N.
Breakfast—		
1 lb. potatoes	45	1·3
¾ pint milk	30	2·5
Melted lard	10	
Dinner—		
1 lb. potatoes	45	1·3
1 pint milk	40	3·4
Lard	10	
Tea—		
1 lb. potatoes	45	1·3
Tea	12	
4 oz. bread (Indian meal or flour)	27·5	1·2
	264·5	11·0

Contrasting the results with the requirements of the standard —*i.e.*, 20 grammes of nitrogen and 320 grammes of carbon—it will be admitted that here again the superiority of the Scotch diet is obvious, and that, indeed, it is the only one of the three which can be regarded as satisfactory.

We may compare with these the diet of an English navvy performing hard work on a railway:

4. *English Navvy.*

	C.		N.
1ST BREAKFAST (5.30 a.m.)—			
Tea	12		
4 oz. bread	29·2	..	1·3
½ oz. butter	10		
2ND BREAKFAST (8.30 a.m.)—			
Tea	12		
6 oz. bread	43·8	..	2·2
½ oz. butter	10		
6 oz. ham	46	..	3·8
DINNER (12 o'clock)—			
Tea	12		
8 oz. bread	58·5	..	2·7
½ lb. meat	34	..	7·5
SUPPER (6 p.m.)—			
½ lb. meat	34	..	7·5
1 lb. potatoes	45	..	1·3
Vegetables—cabbage	? 6·4	..	·5
2 pints beer per diem	28	..	·8
	380·9	..	27·6

This diet, we are told, costs the consumer of it about ten shillings weekly. Compared with the standard, it is a very liberal allowance of food, but not more so, perhaps, than the man's hard work necessitates.

As examples of the other extreme, we may select two cases which are justly described by Professor Oliver as starvation diets. Here they are:

STARVATION DIETS.

A Groom.

	C.		N.
BREAKFAST (8 a.m.)—			
Tea	12		
4 oz. bread	29·2	..	1·3
TEA (5 p.m.)—			
Tea	12		
¼ lb. meat	17	..	3·7
6 oz. bread	43·8	..	2·1
	114·0	..	7·1

A Seamstress.

	C.	N.
Breakfast—		
Tea	12	
1 slice bread, toasted (no butter)	14·6	·6
Dinner—		
1 oz. bacon	21	·1
3 oz. bread	22·2	·9
½ pint milk	5	·4
Tea—		
Tea	12	
2 oz. bread	14·6	·6
¼ oz. butter	5	
Supper (seldom)—		
A saucerful of porridge and milk	? 8	·4
	114·4	3·0

We are not surprised to learn that the first of these cases was admitted into hospital suffering from scurvy and commencing consumption; the second is an example of the small amount of food required to keep body and soul together provided no muscular work is being performed, but under no circumstances can the amount of nutriment contained in it be regarded as adequate.

One of the latest examples of the application of scientific standards in constructing a suitable dietary for the inmates of public institutions is to be found in the instructive report[1] recently presented to the Prison Commissioners for Scotland by their interim medical adviser, Dr. J. C. Dunlop. In this case the prison diets in actual use were analysed, the results being represented in terms of proteid, carbohydrate and fat, and the potential energy yielded expressed as Calories. When compared with the standards already laid down, many of the diets were found to be deficient either in building material or in the amount of energy yielded. New diets are suggested more in accordance with scientific requirements. For the details the reader is referred to the report itself, which contains many interesting examples of the practical application of the standards we have been considering.

In the next chapter I purpose discussing some conditions which influence and modify the amount of food required in health, and dealing also with the results of over and under feeding.

[1] London: P. S. King and Son, 1899.

CHAPTER III

ON THE INFLUENCE OF VARIOUS CONDITIONS UPON THE AMOUNT OF FOOD REQUIRED

1. Work and Rest.

Of all the factors which affect the amount of food required, the influence of work and rest is by far the most potent. This is so much the case, indeed, that all other influences are negligible in comparison with it. We shall consider the influence of **muscular work** first. We may accept Frankland's estimate that a hard day's work for a man of 10 stones would consist in raising his own weight to a height of 10,000 feet, which would be the same as ascending a ladder 2½ miles high. This means the expenditure of 1,400,000 foot-pounds of energy. Now, the equivalent of 1 Calorie in mechanical energy is 3,077 foot-pounds, and if a man is supplied with 3,000 Calories daily, this yields him more than 9,000,000 available foot-pounds of energy. In other words, under ordinary circumstances a man transforms less than one-sixth of the available energy of his food into work, the rest being lost in the form of heat. This loss is inevitable, but it compares favourably with the similar loss in a steam-engine, in which the work done represents at most one-eighth of the potential energy of the fuel consumed.

Seeing that it is not possible to convert any of this waste heat into work, more food must be taken the greater the amount of labour required to be done; and the following may be accepted as standards of the number of Calories which must be supplied for work of different degrees of severity (Rubner):

1. Rest (*e.g.*, clerk at a desk)	2,500 Calories.
2. Professional work (*e.g.*, a doctor)	2,631 „
3. Moderate muscular work (*e.g.*, a house-painter) ..	3,121 „
4. Severe muscular work (*e.g.*, a shoemaker)	3,659 „
5. Hard labour (*e.g.*, a blacksmith or navvy)	5,213 „

A reference to the table on p. 31 will show that even larger

quantities than the last of these are sometimes actually consumed. Brickmakers, for example, whose occupation is one of the most laborious known, were found to take in food to the value of more than 8,000 Calories daily. On the other hand, a German doctor consumed less than 3,000 Calories, although medicine is by no means a sedentary occupation, while the consumption of a Trappist monk, living in the retirement of the cloister, amounted to hardly more than 2,000 Calories per day.

Admitting that with an increase of work there must be a corresponding increase in the total amount of food consumed, the further question arises, In what form is the extra energy to be supplied? Should it be met by an increase of proteid, of carbohydrate or of fat, or should all be increased alike? In attempting to reply to this question, we enter the arena of much physiological controversy, for, stated in another way, the problem we have to solve is this: from what source do muscles derive the energy which enables them to do work? In the earlier part of the present century most physiologists believed with Liebig that nitrogenous matter—in short, proteid—was the muscle food *par excellence*. It was supposed that if much work had to be done, much proteid must be supplied. Soon there arose another school, who contended, and backed their contention with incontrovertible experimental evidence, that, when a bit of hard muscular work is done, it is the carbonaceous, and not the nitrogenous, constituents of the body which suffer increased waste. Of the carbon-containing constituents of the food, the carbohydrates soon came to be regarded as the most valuable sources of muscle energy, a view in favour of which evidence is still accumulating (see p. 272). But, as often happens, our views on this subject have tended to swing back a little with the progress of knowledge, and now physiological opinion seems to have crystallized in a middle position, in which it may be said that a muscle is able to utilize *any* of the nutritive constituents of food for its work, but that, as long as there is a sufficiency of carbon-compounds present, these are preferred to the nitrogenous.

To those who wish to follow the steps which have led to this position of equilibrium, the study of a paper by Dr. Noel Paton in the *Edinburgh Medical Journal* for 1895, p. 1081, may be commended.[1] Dr. Paton compares the advance of our knowledge in this matter to

[1] For some recent experimental evidence leading to the same conclusion see Frentzel ('Ergographic Experiments upon the Restorative Effects of Various Nutritive Substances in Muscular Fatigue'), *Archiv für Anat. und Physiol.*, Sup. Bd., 1899, p. 141.

the tacking of a ship against the wind, and expresses the belief that we have now reached haven in the middle position above referred to, namely, that muscular work makes no special demand on one nutritive constituent of the food more than another.

Direct observation of the diets actually selected by men engaged in severe toil confirms this conclusion. Diets Nos. 16 and 17, 33 and 34, in the table may be taken as examples. It will be observed that in these *all* the nutritive constituents are increased, but that some have elected to consume the excess of carbon in the form of fat, others chiefly as carbohydrate. Both meet the requirements equally well, but carbohydrate has the advantage of being a cheaper source of supply. On the other hand, fat is less bulky, and those who can afford it do well to take in a large share of the increased energy they require in that form. In accordance with this, Oliver tells us that the Northumberland miner consumes a large amount of fat in his diet.[1]

An increase of proteid in the diet of toil is necessary, not so much to provide additional energy as to make good the increased wear and tear of muscle substance which the performance of hard work necessarily involves, as well as, in some cases at least, to enable the muscle to add to its bulk.

From an examination of such diets, the following standards have been constructed, which may serve as guides to the amount of each nutritive constituent required during the performance of hard labour:

Authority.	*Proteid.*	*Fat.*	*Carbohydrate.*	*Calories.*
Voit	145	100	450	3,370
Rubner ..	165	70	565	3,644
Playfair ..	185	71	568	3,750
Atwater ..	150	150	500	4,060

The amount of proteid allowed is in each case considerably above the average standard for moderate work (125 grammes). The sum of carbohydrate and fat is also raised, but in some cases the main increase has fallen upon the former, in others upon the latter. The subject under discussion has important bearings upon **the diet of training.**

Training may be described as a process by which the body is fitted to perform severe muscular feats.[2] The chief means by which one seeks to accomplish this object are the reduction of weight by the removal of superfluous water and fat, and the improvement of the

[1] *Loc. cit.*
[2] See also on this subject Clement Duke's 'School Diet,' chapter xi., 'The Diet in Training for School Games.'

tone of the muscles and heart, which produces endurance and long 'wind.' The first of these objects is attained by reducing the amount of fat in the diet, and by restricting the amount of fluid to that which is required to satisfy actual thirst. That the reduction of fluid in the body is physiologically justifiable is evident from the fact that a watery condition of the muscles and blood does not conduce to an energetic condition of body (see also p. 174). On the other hand, the opposite extreme should be avoided, for a too viscid condition of the blood is equally unfavourable.

No dietetic means have been consciously used to accomplish the second object—the improvement of the tone of the muscles and heart. Experience, however, seems to show that the results of these—*i.e.*, a gain in power of endurance and wind—are attained by increasing the amount of proteid consumed, and in practice this takes the form of eating large quantities of meat. It may be asked if this increased consumption of proteid can be defended on scientific grounds. To some extent, yes. Proteid is the nutritive ingredient least likely to be converted into fat, and is also, on the whole, the most easily digested, and any disturbance of digestion seems to militate greatly against the accomplishment of the objects of training. Moreover, the hard exercise which is practised during training involves a considerable amount of wear and tear in the muscles, and sometimes also an increase in their bulk, and both of these results must be provided for by an increased consumption of proteid.

Further, also, in sudden and short muscular feats, such as those for which training is a preparation, what is required is a large output of energy for a short time. Proteid, being a 'quick fuel,' is probably better adapted to secure this end than either carbohydrate or fat. In recent years there has perhaps been a tendency to lay less stress on the use of meat, to recognise that in training, as in other conditions, the same diet does not suit all persons equally well, and to recommend, rather, the use of ordinary foods, taken in increased quantity, and with the avoidance of anything likely to produce indigestion, such as pastry and sweets. This is probably a move in the right direction; but one would like, on scientific grounds, to see sugar more largely tried.

The tendency would still seem to be to eat too much and at too long intervals. 'He that striveth for masteries,' says the Apostle, 'is temperate in all things.' And this applies to diet as well as to everything else.

The only scientific studies of the dietaries of persons engaged in

athletic exercises, with which I am acquainted, are some that were made in America.[1]

One of these concerns the diet of Sandow, 'the strong man,' and is on that account of some special interest. We read that: 'Mr. Sandow does not follow any prescribed diet, but eats whatever he desires, always being careful to eat less than he craves rather than more. He eats very slowly. . . . Sometimes he takes a cup of weak tea and a little bread in the morning, but usually his first meal is eaten about noon. He eats again about six o'clock, and again about midnight, after his exhibition of feats of strength is over. He smokes a good deal, and drinks beer and other alcoholic beverages.' The following table represents, approximately, Sandow's diet for one day:

SANDOW'S DIET.

Date.	Food Consumed. (*Quantities in Ounces.*)	Nutrients. Proteid.	Nutrients. Fat.	Nutrients. Carbo-hydrates.	Potential Energy.	Nutritive Ratio.
Jan. 10.		*lb.*	*lb.*	*lb.*	*Calories.*	1:
Dinner	2 oysters, 10 soup, 1 celery, 3 fish, 1 potatoes, 2 oyster plant, 1 green peas, 1 tomatoes, 2 bread, 2 roast beef, 2½ chicken, 4 ice cream, 3 orange sherbet, ½ cakes, 1 butter, 11 wine (Burgundy) ..	·17	·14	·34		
Supper	8 roast beef, 7½ rye bread, 3½ Cam-embert cheese, 2 water biscuit, 3½ cakes, 4·4 lb. beer[2]	·26	·14	·61		
Jan. 11.						
Break-fast[3]	9 vegetable soup, 2 potatoes, 3 veal (breaded chop), ½ green peas, 2 roast beef, 4½ bread pudding, ½ cakes, 14 beer	·11	·05	·16		
	Total in pounds	5·4	3·3	1·11	4,462	3·4
	Total in grammes	244	151	502		

'The total amount of food consumed,' says the writer, 'is rather more than the average, though in his own opinion Mr. Sandow is not a large eater. This is in accord with the general conclusion reached in many investigations made with labouring men, that severe muscular exercise requires an abundant diet.'

[1] Langworthy and Beal, Storr's Agricultural Experiment Station, Ninth Annual Report, part ii., 1896.

[2] Sandow sat a long time with friends after supper, and consumed a large part of the beer during this time.

[3] This was the regular lunch served at the hotel

The other dietary study was that of a college football team in active training. The amounts of the nutritive constituents consumed per man were as follows:

Proteid	181 grammes	=5,740 Calories.
Fat	292 ,,	
Carbohydrates ..	557 ,,	

When Weston, the pedestrian, walked 317½ miles in five consecutive days, he consumed only 82½ grammes of proteid per day, but in the five succeeding days his diet was much more abundant, including a good deal of meat. It was estimated to contain 181 grammes of proteid.

Mental work influences the amount and nature of the food required in a very different way from muscular labour. The first thing which it is important to realize clearly is that brain work does not appreciably increase bodily waste at all. On this point all exact experiments agree. One of the most recent and careful of these is recorded by Atwater.[1] A man was confined in a respiration calorimeter for a number of days, and on certain of them he engaged in the severe mental work of reading a German treatise on physics. The subject of the experiment, it may be added, was an intelligent person, who fully understood the nature of the experiment, and did not shirk mental application. It was found that on the working days bodily waste was no greater than during rest.

The next point to get hold of is that *there is no special brain food.* Büchner gave utterance to the dictum, 'Without phosphorus there is no thought.' This is only true in the sense that the brain contains phosphorus, and without the brain, thought, as we know it, is unthinkable. But it has never been shown that an increased supply of phosphorus in the food is specially favourable to mental effort, nor, indeed, has that been proved for any other food. It requires, of course, no special demonstration that an ill-nourished brain is not one from which good work can be expected: for the brain, like every other organ, demands for its work an abundant supply of healthy blood, and there is, perhaps, no part of the body which is more sensitive to any impoverishment of that fluid. This is the physiological justification of the movement in favour of free or cheap meals for our Board School children. Less caning would probably prove the corollary of more feeding. On the other hand, any oversupply of food must be equally unfavourable to mental work. A large amount of food implies a large amount of work on the part of the

[1] United States Department of Agriculture, Bull. 44, 1897.

digestive organs, and that, in its turn, implies a large expenditure of nervous energy and blood. But if more blood is required in the abdomen, there must be less left for the brain, and the activity of the latter declines, as is evidenced by the feeling of lethargy which is familiar to everyone after a large meal. It comes, then, to this, that *the digestibility of a food is of far greater concern to a brain worker than its chemical composition.* Small and rather frequent meals of easily-digested food is the ideal to aim at. The necessity for this is the more apparent when one remembers that brain work is usually also sedentary work. Compared with the diet of muscular labour, therefore, the diet for mental work should be small. The reduction should probably affect the carbohydrates and fats more than proteid, for it is the two former, as we have seen, which tend to be specially made use of as muscle foods. The proteid consumed should be to a large extent derived from animal foods, for these are its most compact and digestible source. Hence it is that it is far easier for a man who is performing bodily labour to be a vegetarian, than for one who is engaged in mental work. Whether an abundant supply of proteid has, *per se*, an actually stimulating influence on the brain must be left undecided, though such a view is not without its supporters.[1]

Rest, as might be expected, influences the amount of food required in a precisely opposite direction to muscular work. Much less food is required in the former condition than in the latter. The reduction, however, should not affect all the nutritive constituents equally. Even when the body is in complete repose there is still wear and tear of its substance going on. Such waste, indeed, is inevitable, for it is an invariable accompaniment of even passive life, and one finds that during rest the excretion of carbonic acid is much more profoundly influenced than that of nitrogen. The practical result of this is that in the diet of repose the carbohydrates and fats should be relatively more restricted than the proteids. The energy value of such a diet may even fall to 2,000 Calories or less, and yet prove sufficient for the bodily needs. This is a fact of great value in therapeutics. It explains why it is that one has so much less difficulty in fattening a patient when he is at rest in bed than when he is up and about, for under these conditions the demand both for heat and energy is enormously lessened. Sleep intensifies the benefits of rest by insuring more absolute relaxation of the muscles, and also seems in itself to lessen somewhat the waste of fat. A German

[1] See Roberts, 'Digestion and Diet,' p. 109.

writer (Lobisch) goes so far as to assert that an extra hour's sleep at night is equivalent to a saving of 2¼ pounds of fat in a year.

2. Influence of Weight and Build.

The heavier the body—*i.e.*, the greater the number of cells which it contains—the greater is the amount of food required for its maintenance. This is true as a general statement, but in practice the *kind* of cell which is increased must also be considered. The nutritive requirements of a pound of bone, a pound of fat, and a pound of muscle are very different. Fat and bone are, so to speak, dead tissues. Their vital activity is but slight, their daily wear and tear small. Muscle, on the other hand, is a highly active tissue constantly breaking down, and requiring not merely much proteid to repair its waste, but making frequent demands on the carbonaceous foods to provide it with a supply of energy.[1] Thus it is that a man whose weight is mainly due to muscle will require relatively more, and especially more nitrogenous, food than one who owes his weight to the size of his bones or to a substantial covering of fat. Taking the average man, however, and assuming him to be engaged in moderate muscular work, it may be reckoned that he will require to be supplied daily with 35 Calories of energy for every kilo (2 pounds) of his weight. Expressed in terms of nutritive constituents, one may put it at about ⅔ gramme of proteid, 3 grammes of carbohydrate, and ½ gramme of fat for every pound.

The **build or shape** of the body is of even greater importance in this connection than its actual weight. Further, we may say that the question of build and shape, as far as the amount of food required is concerned, resolves itself into a question of surface. The larger the surface of the body relative to its bulk, the greater is the amount of heat lost by radiation, and the greater the amount of food required to maintain its temperature. A reference to the accompanying diagram

[1] Dr. Smith (*Lancet*, May 21, 1864) gives the amount of fat consumed under different conditions as follows:

One hour of lying asleep consumes	0·31 ounce.
„ „ lying awake „	0·46 „
„ „ standing „	0·55 „
„ „ walking at two miles per hour consumes	1·1 ounces.
„ „ „ three „ „ „	1·6 „
„ „ work on a treadmill consumes	2·75 „

Ranke compared the output of two men of equal weight, one fat, the other muscular, and both fasting, with the following results:

	Muscular Man.	*Fat Man.*
Proteid	78	50
Fat	215	204

(Fig. 2) will make this clear. Let us suppose that we have two bodies, the first being 9 feet high, 3 feet broad, and 1 foot thick, and the second measuring 3 feet in every dimension. Both will have a cubic content of 27 feet, but the first will have a surface of 78 square feet, the second of only 54 square feet; in other words, the surface exposed is almost one-third greater in the one case than in the other, and the amount of heat lost will also be proportionately greater. The first of these figures would represent the condition of a tall, thin man, the second that of a short, stout man; and as the former must lose about one-third more heat than the latter, he will obviously require about one-third more fuel in the form of food if the temperature of the two is to remain equal. This explains the apparent paradox, which is otherwise apt to prove rather puzzling, that a thin man often eats considerably more food than a fat man, yet the former remains lean and the latter becomes more and more stout. The former really needs more food simply because he *is* thin; while the fatter a man becomes, the less food does he require, for with every increase in bulk there is a corresponding diminution in the relative amount of surface exposed. When one estimates the amount of Calories required from the point of view of surface rather than of mass (body-weight), it is remarkable how uniform the requirement is for all persons living under the same external conditions. The extent of body-surface in an average man is about $21\frac{1}{2}$ square feet, and for every $10\frac{3}{4}$ square feet about 1,500 Calories must be supplied daily.

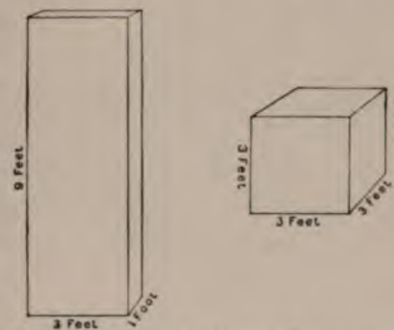


FIG. 2.—TO ILLUSTRATE THE INFLUENCE OF SHAPE ON EXTENT OF SURFACE.

3. INFLUENCE OF AGE AND SEX.

It seems to be a general principle in biology, that the younger a cell is the greater is its power of oxidizing and breaking down food, and that the older it is the less of this power does it possess; in other words, what the cells of the body gain in number by multiplication they lose in individual activity. In accordance with this principle, the assimilative powers of a child are found to be greater than those of an adult, and those of the latter greater than those of

an old man. The **child**, therefore, relatively to its weight, will require the greatest amount of food.

Two other considerations emphasize this necessity. Like all small animals, a child has a large surface in proportion to its bulk, and that means, as we have just seen, a relatively large heat loss. Further, a child is a *growing* animal; it has not merely to keep its tissues in repair, but has to go on adding to them, and that necessitates a relatively large supply of building material.

The practical results of these considerations will be more fully dealt with in another chapter (Chapter XXIV.), but it may be stated here that they have led to the following calculations regarding the total amount of food required in childhood as compared with the needs of a fully-grown man (Atwater):

A child under 2	requires	0·3	the food of a man doing moderate work.
" of 3 to 5	"	0·4	" " " "
" of 6 to 9	"	0·5	" " " "
" of 10 to 13	"	0·6	" " " "
A girl of 14 to 16	"	0·7	" " " "
A boy "	"	0·8	" " " "

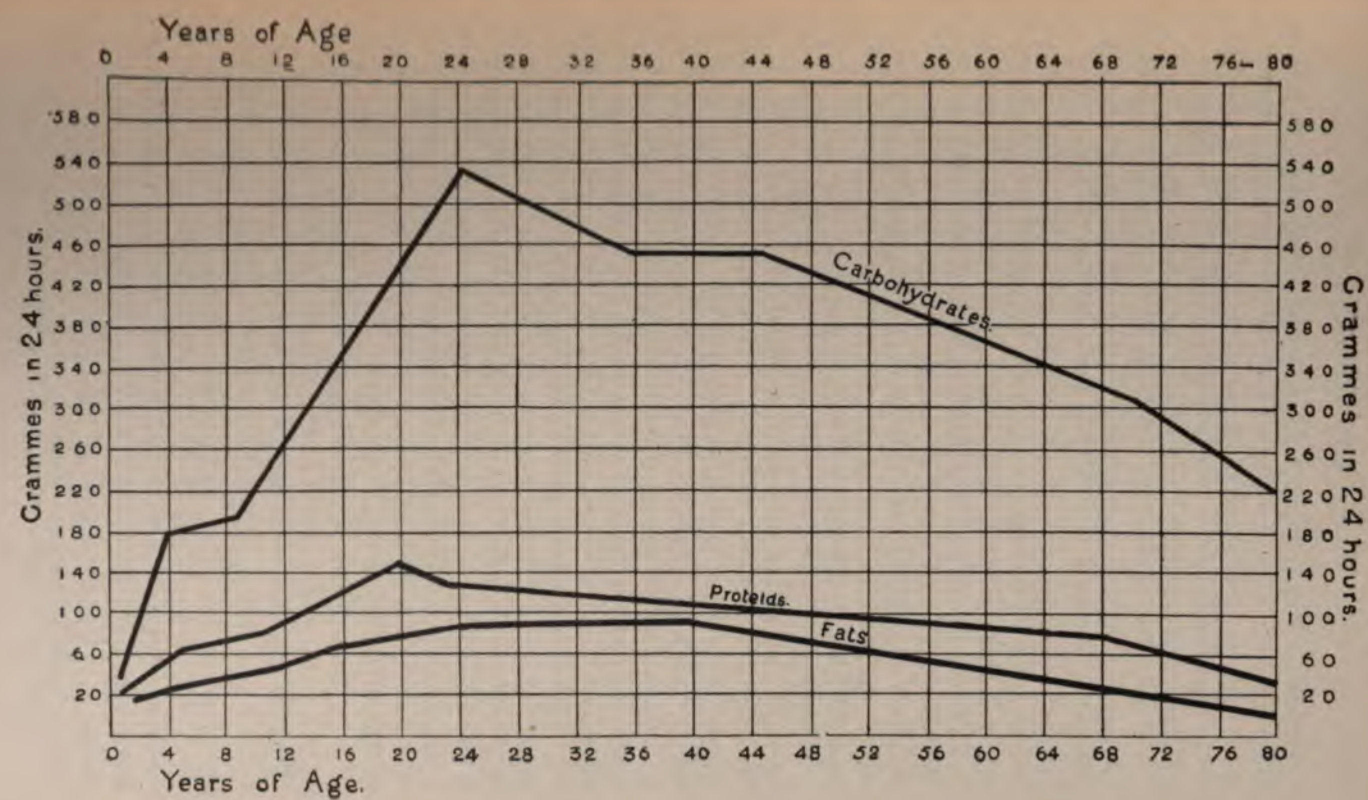
The 'nutritive ratio' (*i.e.*, the proportion of building material to energy-yielding constituents) in the diet of an adult should be, we have seen (p. 27), as 1 : 5·3, or thereabouts. In the diet of a child the ratio should be approximately as 1 : 4·3.

The dietetic requirements of **old age** are just the reverse of those of childhood. The assimilative power of the cells is on the wane[1] and the bodily activities are restricted, hence less food is required. The danger of overfeeding the old is almost as great as that of underfeeding the young; an excess of nourishment chokes instead of feeding the flickering flame of life. Leanness and longevity, it has been remarked, go together, and a man will only roll all the faster down the hill of life if his figure be rotund. 'Discerne,' says Bacon, 'of the coming on of yeares, and thinke not to doe the same things still, for Age will not be defied,' and one cannot with impunity continue to 'do the same things' in matters of diet any more than in anything else.

Forster made some exact investigations into the diet of healthy old persons, and found that it contained the following amounts of nutritive constituents:

	Proteid.	*Fat.*	*Carbohydrates.*	*Calories.*
Men	92	45	332	2,149
Women.. ..	80	49	266	1,875

[1] Von Limbeck, 'Zur Lehre vom Stoffwechsel im Greisenalter,' *Zeits. für Klin. Med.*, xxvi. 437, 1894. See also Sir Henry Thompson's 'Diet in Relation to Age and Activity' for a practical discussion of the subject.


Years of Age
Grammes in 24 hours.
Carbohydrates.
Proteids.
Fats
Years of Age.
Grammes in 24 hours.

The results fully bear out the above contentions. In the preceding diagram (Fig. 3) the amount of each nutritive constituent required at different periods of life is represented. While the figures must not be regarded as in any sense absolute, they serve to represent in a graphic way the relative requirements of different ages.

Cornaro is one of the most eloquent advocates of temperance in old age. 'It cannot be urged too often,' he writes,[1] 'that when the Natural Heat begins to decay 'tis necessary for the preservation of health to abate the quantity of what one eats and drinks every Day; Nature requiring but very little for the Support of the Life of Man, especially that of an Old Man.' He tells us that he ate only 12 ounces of solid food daily, consisting chiefly of bread, wine, broths and eggs, veal, mutton, partridges, chicken, and pigeons, and some kinds of fish, such as pike, for 'all of these aliments,' he adds, 'are proper for old men.' His system was certainly justified by its results, for he is said to have lived to be a hundred years old.

Women require less food than men, for their bodies are not only, as a rule, of less weight, but are relatively richer in fat and poorer in muscle than those of the latter. Further, there is a considerable amount of evidence for the belief that the cells of the body are less able to carry out oxidation changes in the female than in the male; or, in physiological language, that the tendency of metabolism is in the direction of a preponderance of anabolism in the one case, and of katabolism in the other. Upon this supposition a whole theory of sex differences has been based.[2] Whether this be so or not, there can be no doubt that the diet of the female should be less in amount than that of the male; and it has been estimated that, if a man consumes 10 parts of food, a woman under similar conditions should require only 8 parts. Expressed in terms of nutritive constituents and Calories, the diet of an average woman doing a moderate amount of muscular work should be as follows:

Proteid.	*Fat.*	*Carbohydrates*	*Calories.*
90	40	400	2,381

The proportions in a condition of rest would be:

Proteid	85
Fat	40
Carbohydrates	320

yielding about 2,000 Calories of energy. When one conside[rs the] relative requirements of the two sexes, it is not surprising th[at]

[1] 'Sure and Certain Methods of Attaining a Long and Healthful L[ife,' trans]lated from the fourth edition; London, 1727, p. 91.

[2] Geddes and Thompson, 'Evolution of Sex,' 1889.

of the most aggravated cases of obesity should be met with in women of luxurious life.

4. Influence of Climate and Season.

The influence of **climate**, and especially of a warm climate, on the amount of food required is commonly exaggerated. It seems natural to suppose that, if the surrounding temperature is high, the amount of heat required to be produced in the body will be less. But this is to lose sight of the fact that the temperature of the body is chiefly regulated by *physical*, and not by *chemical*, means. To put it more plainly, we adjust the temperature of our bodies to that of the surrounding medium, not so much by the expensive method of increasing or diminishing the amount of heat we produce, as by the simpler expedient of regulating the amount of heat lost.

Heat and life, as has been already pointed out, are inseparable. We cannot *help* producing a certain amount of heat if we are to go on living at all. Now, thanks to the fact that we wear clothes, we live in an atmosphere of about 90° Fahr.—that is to say, in what is practically a tropical climate. At this temperature the amount of heat produced in the body is in excess of its requirements, even when that production is as small as is compatible with the full activity of our cells. This means that, even in a temperature of 90°, we are constantly wasting a certain amount of heat. Suppose, now, that one goes into the tropical regions. As the external temperature rises, the amount of heat which the body requires becomes less and less; but already as little is being produced as is compatible with health, so that, in order to adjust the balance, one must not try to diminish the production by eating less food, but rather to increase the loss by wearing thinner clothes. In harmony with this, one finds, as a matter of fact, that the actual amount of food consumed by the inhabitants of the tropics is not notably less than the consumption of those who live in the temperate zone.

Suppose, on the other hand, that one moves from a temperate to a colder latitude. The body will now require more heat to keep its temperature up to the normal level, and the first method had recourse to in order to meet the increased demand is by economizing waste, or, in other words, by diminishing the amount of heat lost. In practice, this is accomplished by an increase of clothing. If the external temperature falls still further, however, this method by itself becomes inadequate, and steps must be taken to increase heat production; it is only then that it becomes advisable to consume more food.

'During the whole of our march,' says Sir John Franklin, in describing his journeyings in the Arctic regions, 'we experienced that no quantity of clothing could keep us warm while we fasted, but on those occasions on which we were enabled to go to bed with full stomachs we passed the night in a warm and comfortable manner.' Translated into physiological language, this means that the demand for heat in the body was so great that it could no longer be met by diminishing loss, but that the deficit had to be made up by an increase of heat production—*i.e.*, by a greater consumption of food.

What form the increased consumption of food takes is, comparatively speaking, of little moment. All that is really necessary is that the number of Calories which the diet is capable of yielding should be considerably raised. As a matter of convenience, however, and in order to avoid overfilling the stomach, it is best to have recourse to fat as the principal source of the extra heat required, for fat is the compactest form of fuel we possess. Carbohydrates would serve the purpose equally well as far as the cells of the body are concerned, but one would require to consume more than twice as much of them as of fat in order to obtain the same amount of heat. Besides, in very cold latitudes carbohydrates are not so easily obtained as fat. This is the explanation of the enormous quantities of blubber which the Esquimaux consumes, as much as 20 pounds of flesh and blubber, we are credibly informed, being eaten in the course of a day in some cases. A similar adaptation to circumstances on the part of Nature is seen in the milk of the walrus, which contains 40 per cent. of fat, thus supplying the young with an abundant and compact source of fuel, and enabling them to maintain their temperature in the icy waters of the North.

The influence of **season** on the amount of food required is similar in kind to the influence of climate, though less in degree. In summer clothing should be diminished rather than food; in winter warmer clothing should be worn, but the amount of food, and especially the proportion of fat which it contains, may with advantage be increased. It also seems reasonable to avoid in warm weather what have already been described as the 'quick fuels'—*i.e.*, those nutritive constituents from which a large amount of heat can be produced in a short time, and especially the proteids. For this reason, as well as from the fact that they are relatively rich in fat, the animal foods should be more sparingly consumed in summer, and the proportion of vegetable matters in the diet relatively increased.

5. Influence of Personal Peculiarity.

There is a widespread impression that some people can 'get on' with less food than others, even although they are living under identical external conditions. We hear it said of one man that he is always eating, and yet remains thin and languid; of another, that he lives the life of an ascetic, and yet grows hearty and fat.

To a large extent these apparent results are explicable by the differences of weight, build, and shape of body, which we have already studied; but even giving such considerations their full weight, there remains some room for the belief that some people really do make better use of their food than others. To use a popular phrase, they 'put it into a better skin.' Scientific evidence on this point is very difficult to obtain. Remembering, however, that the utilization of food is a function of living protoplasm, it is at least conceivable that in some persons the activity of the cells is greater than in others, and leads to a more rapid breaking down of food and a greater waste of heat. It has been clearly proved by scientific experiment that a man who is skilled through long practice in doing any particular piece of muscular work will do it with less expenditure of bodily material, as expressed in the excretion of carbonic acid and nitrogen, than a novice. In other words, and as far as that particular kind of work is concerned, the former is a more economical machine than the latter, and there is really no very apparent reason why there should not be degrees of such economy in the performance of all the functions essential to life.

The **influence of the nervous system** in regulating tissue waste must also be borne in mind. The functions of nutrition and assimilation seem in some mysterious way to be under the dominion of the central nervous system, and if the control so exercised is diminished there may be a tendency to increased waste of tissue, just as we know that there is in a paralysed limb. But the degree in which the nervous system exercises its functions differs enormously in different persons, and so it is not altogether incredible that the degree in which bodily waste is controlled may differ also.

Be this as it may, there is no more practical fact in dietetics than the different results which the same food, either in quantity or in kind, produces in different persons, and it has to be constantly borne in mind in regulating the diet of the sick. A study of the habits of different nationalities reveals the same thing. The German is notoriously a larger feeder than the Frenchman, a fact which was clearly evidenced in the commissariat arrangements in the Franco-

Prussian War, and Americans certainly consume more food per head than Englishmen in the same conditions of life. Even granting, which might be disputed, that the output of work and energy is greater per individual in America than in Europe, the difference is not entirely explained, and may perhaps rest on some inherent constitutional cause. Anyhow, a consideration of facts such as these should warn one of the dangers of dogmatism in matters of diet. We can and may lay down rules as to the kind and amount of food required under different circumstances, but we are treading on dangerous ground when we come to apply these rules to individual cases. In the matter of diet every man must, in the last resort, be a law unto himself; but he should draw up his dietetic code intelligently, and apply it honestly, giving due heed to the warnings which Nature is sure to address to him should he at any time transgress.

Having considered the kind and quantity of food required in health, and the way in which these are affected by various bodily conditions and states of life, we may now glance for a moment at the general effects of an excessive or a deficient supply of food respectively.

Overfeeding.—It is, perhaps, no exaggeration to say that the tendency of civilized peoples, and especially of the upper classes in civilized society, is to eat too much. Feeding is pleasurable as well as necessary, and when the necessities of the body have been supplied, the process is apt to be continued merely for the sake of the pleasure which it affords. Now, a *moderate* excess of food is probably harmless, if not actually beneficial. It is not safe to sail too near the wind in matters of diet. As a French writer has paradoxically put it: 'Pour avoir assez il faut avoir trop.' For it is well to have some reserve in the body which can be called upon if one is compelled for any reason to go for some time without any food at all. The presence of such a reserve can only be insured by the habitual consumption of rather more food than is required to meet the bare necessities of the body. It is in this way, too, that the occasional indulgence in an unusually heavy meal can be justified. There are some, for instance, who see in the large Sunday dinner of the workman a partial provision for the wants of the whole week.

Leaving aside the consideration of this surplus, which can hardly be described as an excess, one has to look at the results of acute and chronic overfeeding separately. The injurious effects of consuming a great excess of food at one time are local rather than remote. They fall chiefly upon the digestive organs. The overburdened

stomach may relieve itself by vomiting, or, if the food is passed on into the intestine, it is apt to undergo decomposition before it is all absorbed, and be carried off by diarrhœa. That these effects may sometimes be sufficiently severe is evidenced by the fact that people have been known to die of a 'surfeit,' though in modern days such a result must be regarded as very rare, always excepting those instances in which even moderate overloading of the stomach may have too much hampered the action of an already feeble heart.

If the process of absorption goes on too rapidly for assimilation to keep pace with it, the blood seems to be able to rid itself of some, at least, of the surplus products of digestion by aid of the kidneys. Thus, a great excess of proteid in the food may give rise to transient albuminuria, while sugar may temporarily appear in the urine after an extravagant consumption of carbohydrates. This method of adjusting the balance, however, seems to be one which is but seldom had recourse to.

The general results of habitual or chronic overfeeding are more insidious, and seem to vary with the nutritive ingredient which is specially indulged in. If this be carbohydrate or fat, the surplus is simply stored up in the form of fat, and obesity results. In the case of proteid such storage is hardly possible, for so great is the tendency of 'nitrogenous equilibrium' to assert itself that the body can only 'lay on' proteid for very short periods, unless the process of growth is still going on. What usually appears to happen is that the surplus proteid is split up into two portions, one of which contains most of the carbon and is probably converted into fat and stored in that form, while the nitrogen-containing part is broken down, but not, perhaps, very rapidly and completely; so that the products which represent the intermediate steps in its destruction circulate for some time in the blood before being excreted in the form of urea. It may be that some of these products are concerned in the production of such diseases as granular degeneration of the kidneys, gout, and rheumatism; but that is a point on which it is not yet advisable to speak very dogmatically. It must be remembered, too, in this connection that an excess of proteid sparers in the blood may produce very similar results to an excess of proteid itself by shielding the latter from complete and rapid oxidation.

Underfeeding.—It is astonishing how long the body can go without food provided a due supply of water is obtainable. Lunatics have been known to refuse food for four or five weeks at a stretch, and the experience of professional fasters shows that long periods of starvation can be borne with impunity. Experiment, indeed, has

shown that it is only when the weight of the body has fallen to one-half or one-third its original amount that death from inanition ensues. It is well to remember these facts when dealing with cases of acute disease. One is very apt to flatter himself that he is keeping a patient alive by, say, rectal feeding, when all the time the patient is really living on his own tissues. Nor need one be unduly alarmed if a well-nourished patient is unable to take any food at all for a few days. His own reserves will be able to tide him over the emergency without much injury.

Of chronic or habitual underfeeding as a whole it may safely be said that it is more injurious than the opposite condition of intemperance in food. One has to recognise also that a relative lack of one nutritive constituent is probably commoner than a deficiency of all, or, in other words, that an **ill-balanced diet** is more frequently met with than one which is defective all round. As nitrogen is the element of which the body is mainly built up, a lack of proteid in the food seems to be more injurious than a shortcoming in respect of carbohydrate or fat. As I have already referred to this point (p. 23), it need only be repeated here that an insufficient supply of proteid leads to imperfect tissue repair, more especially, perhaps, of the muscles and blood;[1] that it causes the body to become unduly watery, whence the pallor and puffiness of the underfed; and that the combined effect of these results is to produce a lowering of the power of resistance to unfavourable influences, including disease.

It must not be concluded that merely because a man is fat he cannot at the same time be underfed. On the contrary, obesity is quite compatible with an insufficient supply of nitrogenous nutriment, and many of the most intractable cases of corpulence—those, namely, in which the patient is pale and flabby as well as fat—are just those in which the nitrogenous tissues of the body are to be regarded as being in a state of imperfect formation and repair. It is probably for this reason that fat persons often stand depletory measures, such as purging and bleeding, worse than those who are in appearance not so well nourished.

The effects of insufficient feeding in diminishing resistance to cold have already been alluded to (p. 50), and were strikingly seen in some episodes of the American Civil War, a detailed account of which has been provided by Flint.[2] Its effects in producing liability to disease were well illustrated in the outbreaks of relapsing fever

[1] For experimental evidence, see Subbotin, *Zeitsch. für Biologie*, vii., 1871, p. 185.
[2] 'Physiology of Man,' New York, 1867, p. 35.

and typhus which followed the potato famine in Ireland[1] in the early part of this century, and similar results have repeatedly been witnessed in India and elsewhere, fever and plague dogging the footsteps of famine. It has also been pointed out that exposure to infection is specially apt to be dangerous on an empty stomach, as, for example, before breakfast, a fact which it is specially important for members of our profession to bear in mind.

The tubercle bacillus seems to find a specially favourable soil in ill-nourished persons. The association between bad feeding and such diseases as phthisis and scrofula is well established, while an improvement in nutrition is not infrequently followed by their cure. This may be the reason why diabetics, who live in a chronic state of partial starvation, are so liable to tuberculosis, and tall men, who, for reasons already discussed, have less food to spare than their fellows of less stature, are believed to be more subject to consumption than the latter are.

Epidemic ophthalmia is another disease which seems prone to select the underfed as its victims, and it might be well when it breaks out, as it is so apt to do, among the children of Poor Law schools and other public institutions, to look more to the possibility of defective diet and less to overcrowding as the cause.

It is considerations such as these which entitle one to regard the repeal of the Corn Laws, which has done so much to cheapen food in this country, as a hygienic quite as much as an economic measure, and the diminished death-rate which has been so conspicuous in the latter part of the present century may have had more to do with it than one commonly thinks.

The bad effects of underfeeding fall most heavily upon the young, for the greater the demand on the part of the body for food, the more severely is any deficiency felt. The recognition of this fact is as old as Hippocrates, who devoted a special aphorism to the statement of it. 'Old men,' it runs, 'bear want of food best; then those that are adults; youths bear it least, most especially children, and of them the most lively are the least capable of enduring it.'

The remote results of underfeeding are not less injurious than its more immediate effects. Amongst such results, impairment of digestive power is very conspicuous. The danger of stuffing a starving man is notorious, but even in chronic underfeeding the same weakening of the digestive organs is observed. It is often seen in dyspeptics. The more their nutrition fails through not eating, the less they are able to digest, and the first step in curing their

[1] See Life of William Stokes in 'Masters of Medicine' Series, p. 110 *et seq.*

stomach troubles must often be in the direction of compelling them to eat more.

Another of these remote dangers is in the influence of imperfect feeding upon the mind. I refer not merely to a lowering of mental power, but to that feeling of dissatisfaction, discomfort, and depression, culminating sometimes in madness and hallucinations, which imperfect nutrition of the brain is apt to produce.

'A hungry man is an angry man,' and the proverbial good nature of the Englishman may, perhaps, be associated with the fact that, as a rule, he is full fed. The dangers here alluded to have been eloquently described by Dr. King Chambers[1] in the following passage, with which I may close this chapter:

'Deficient diet, like all morbid conditions, both corporeal and mental, is a vitiating and degenerating influence. Famine is naturally the mother of crimes and vices, not only of such sort as will satiate the gnawing desire for food, but of general violence and lawlessness, ill-temper, avarice, lust, and cruelty.

'The love of purposeless destruction exhibited by the Parisian Communists in our own day may be fairly credited to deficient food. No well-fed people could have wrecked the Vendôme Column or burnt the Town Hall and Tuileries, of which they were so proud. They were like hungry children smashing their dolls. And Thucydides, Boccaccio, and Defoe are all agreed as to the hideous wickedness exhibited at Athens, Florence, and London during their famine-fevers. The exceptional instances are those where individuals or nations have conquered by courage and self-restraint their natural selfishness, and have made the interests of others paramount to their own. Am I blinded by love of my country, or may I justly quote the history of the Lancashire cotton-famine as a case in point?'

[1] 'Manual of Diet in Health and Disease,' second edition, 1876, p. 223.

CHAPTER IV

ANIMAL FOODS

IN previous chapters we have dealt with foods in general. We have studied the nature and uses of their nutritive constituents, the standards by which one judges of their relative values, the amount of food required to maintain the body in a state of health, and the directions in which this amount must be modified in accordance with various influences and conditions. We have also glanced at the general results of over and under feeding. In this and a number of succeeding chapters we shall undertake the study of individual foods in detail, and in dealing with each it will be well to consider (1) its physical structure and chemical composition; (2) its behaviour in the stomach and intestine; (3) its nutritive value in the body; (4) its real cost.

We may begin our studies with foods derived from the animal kingdom; but it will be well to defer the consideration of the general characters of the group as a whole until we are in a position to contrast them with the vegetable foods.

A convenient classification of the animal foods is as follows:

1. Meat, including the several varieties of butcher's meat, poultry, game, and 'offal.'
2. Gelatin and the foods prepared from it (jellies).
3. Soups, beef-extracts and beef-powders, beef-tea and beef-juices.
4. Fish and its allies.
5. Milk and its derivatives, including cream, butter, and cheese.
6. Eggs.

1. MEAT.

We may look first at the **physical structure** or architecture of meat (Fig. 4).

If one examines a piece of boiled meat, it will be found that it can easily be torn into a number of long, stringy fibres. On micro-

scopic examination, these would be found to be made up in their turn of bundles of microscopic tubes, known to the histologist as muscle fibres. The fibres vary in length in different kinds of meat. Sometimes they are short, as in the breast of a chicken; at other times they are much longer, as in the leg of a crab; and the shorter they are, the more tender and easily digested the meat is. Meat should be cut or carved at right angles to the long axis of the fibres. It is then more easily chewed, and, the contents of the tubes being exposed, the flavour of the meat is improved, while the readier access which the digestive juices have to the contents favours rapid solution in the stomach.

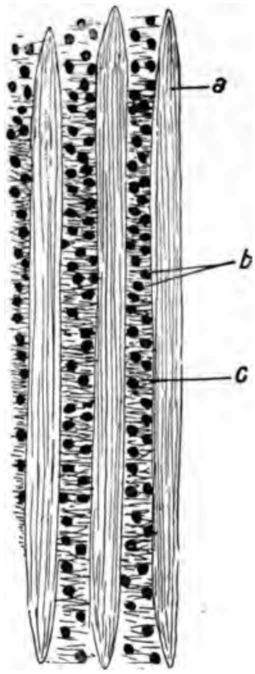


FIG. 4.—DIAGRAMMATIC REPRESENTATION OF THE STRUCTURE OF MEAT.
a, Muscle fibres; b, Fat cells; c, Connective tissues.

The walls of the tubes consist of an albuminoid substance (elastin), while the connective tissue which holds together the fibres is chiefly composed of a material called 'collagen,' which yields gelatin on boiling. The older an animal is, and the more work its muscles have had to perform, the denser is the connective tissue and the thicker the walls of the tubes. The latter fact was long ago pointed out by Dr. Kitchener in his 'Cook's Oracle.' 'That exercise produces strength and firmness of fibre,' he says, 'is excellently well exemplified in the woodcock and partridge. The former flies most, the latter walks; the wing of the woodcock is always very tough, of the partridge very tender; hence the old doggerel distich:

> 'If the Partridge had but the Woodcock's thigh,
> He'd be the best bird that e'er doth fly.'

Embedded in the connective tissue between the fibres is a variable amount of fat. Sometimes it is almost entirely absent—*e.g.*, in most forms of game and in the breast of the chicken; at other times the amount of fat so placed is quite abundant. This is the case in pork, in highly-fattened beef or mutton, and in swimming birds, such as the duck and goose, which require a large store of fat, both to lighten the body and as a source of fuel. A large amount of fat tends to

diminish the digestibility of meat, apparently by forming a sort of waterproof coating around the fibres and hindering their solution by the gastric juice, and it is notorious that pork, duck, and goose are rather indigestible forms of flesh.

The **contents of the microscopic tubes or muscle fibres** consist of water holding in solution proteids, salts, and the substances known as 'extractives,' the whole constituting muscle-juice. The younger the animal, the more **water** does its flesh contain, and the lower is its nutritive value. This may be the explanation of the German saying, 'Calf-meat is half-meat.'

The chief **proteids** which the juice contains are myosin, muscle albumin, and hæmoglobin, the first being the most important. Myosin has the property of clotting after death, the hardening of the muscle which results being known, it will be remembered, as **rigor mortis**, or death-stiffening. Meat in that condition is tough, and accordingly, if tenderness is desired, the meat should be eaten either immediately after the animal is killed, and before rigor mortis has had time to set in, or else it should be allowed to hang till the rigor has passed off. The disappearance of rigor is due to a re-solution of the myosin by the development of acids,[1] and to a partial digestion of it by the traces of pepsin which muscle contains. The process must be regarded as an early stage of putrefaction, and, as is well known, if the meat be allowed to hang for some time longer it becomes 'high.'

The **acids** which develop in meat on hanging aid the gelatinization of the connective tissue which occurs on boiling, and also improve its flavour by removing the rather insipid flatness of taste which characterizes very fresh meat. In the flesh of animals which have undergone great muscular exertion immediately before being killed there is a considerable quantity of acid present even at the time of death. Hence the flesh of hunted animals is of a superior flavour, and in less humane ages and countries attempts have been made to develop this flavour in domestic animals artificially by urging them to frantic exertions before slaughter. Another way of producing these effects by artificial means is by soaking the meat in vinegar and water for a short time. This is found to improve the flavour of fresh meat, as well as its tenderness. It is partly for the same reason that the use of vinegar favours the digestibility of the rather hard muscles of the crab and lobster.

The amount of **hæmoglobin**, or red colouring matter, in the juice varies greatly in different kinds of meat, and is usually less in

[1] Sarcolactic acid and acid phosphates.

amount in that obtained from young animals. It is of importance as containing iron. Hæmoglobin is also found in the small blood-vessels which form a network around the fibres of meat. In animals which have been bled to death it is much diminished in amount or altogether removed; hence the pallor of veal.

The chief **mineral substances** found in the juice of meat are phosphoric acid and potash. Meat must be regarded as one of the principal sources of these valuable building materials in the diet, and if they are insufficiently supplied, the muscles are flabby and badly developed.

Last, but not least, of the substances contained in solution in the juice of meat are the **extractives**. These are so called because they can be 'extracted' from meat by means of boiling water, and are familiar to everyone as the dark brown, sticky material which constitutes the chief part of Liebig's Extract. We shall have much to learn about these extractives later on, but it may be stated here that their exact chemical nature is to a large extent unknown, that they have no nutritive value, but are of importance as being the chief cause of the characteristic taste of meat, and that, therefore, when they are removed, as they are, for example, on prolonged boiling, the meat becomes flavourless and insipid. Further, it would appear that the **characteristic flavours of the different kinds of meat** are due to minute differences in the amount and kind of the extractives present. The age of the animal and the way in which it is fed are of great importance in this connection. The flesh of full-grown animals is richer in extractives and has a fuller flavour than the flesh of those which are immature, which explains why we eat lamb with mint sauce and add spices to veal. The influence of feeding, on the other hand, is well illustrated by all forms of game. The flesh of wild rabbits, which eat aromatic herbs, especially thyme, has a much finer flavour than that of rabbits which are fed by hand, and a slice of wild duck is generally admitted to be a more tasty morsel than a piece of the corresponding bird reared in a farmyard. Everyone knows, too, how 'fishy' sea-birds taste, how superior hill mutton is to its turnip-fed substitute, and how in grouse or capercailzie one can detect, as it were, an echo of the aroma of the heather-tops or pinewoods amongst which these birds live.

The **chemical composition of meat** varies considerably, depending as it does on the particular 'cut' examined, on the degree to which the animal has been fattened, etc. It must be noted, also, that by no means the whole of ordinary butcher's meat consists of edible

matter, a large part being made up of bone, gristle, tendon, and other inedible portions. In an average piece of meat these **waste matters** may be reckoned at 15 per cent. of the whole, and the **proportions of the constituents** in the edible part are about as follows (König):

Water	75 to 77 per cent.
Muscle fibres	13 to 18 ,,
Connective tissue	2 to 5 ,,
Fat	½ to 3 ,,
Ash	0·8 to 1·8 ,,
Extractives..	½ ,,

Other analyses represent the proportions of the chemical substances present thus:

100 Parts of Lean Beef without Visible Fat (Bischoff and Voit).		*100 Parts of Dry Substance (Rubner).*	
Proteid	18·36	Syntonin, myosin, and gelatin	70·1
Gelatin	1·64	Hæmoglobin and serum albumin	8·57
Fat	0·90	Muscle albumin	3·13
Extractives	1·90	Extractives	12·68
Ash	1·30	Ash	5·50
Water	75·90		

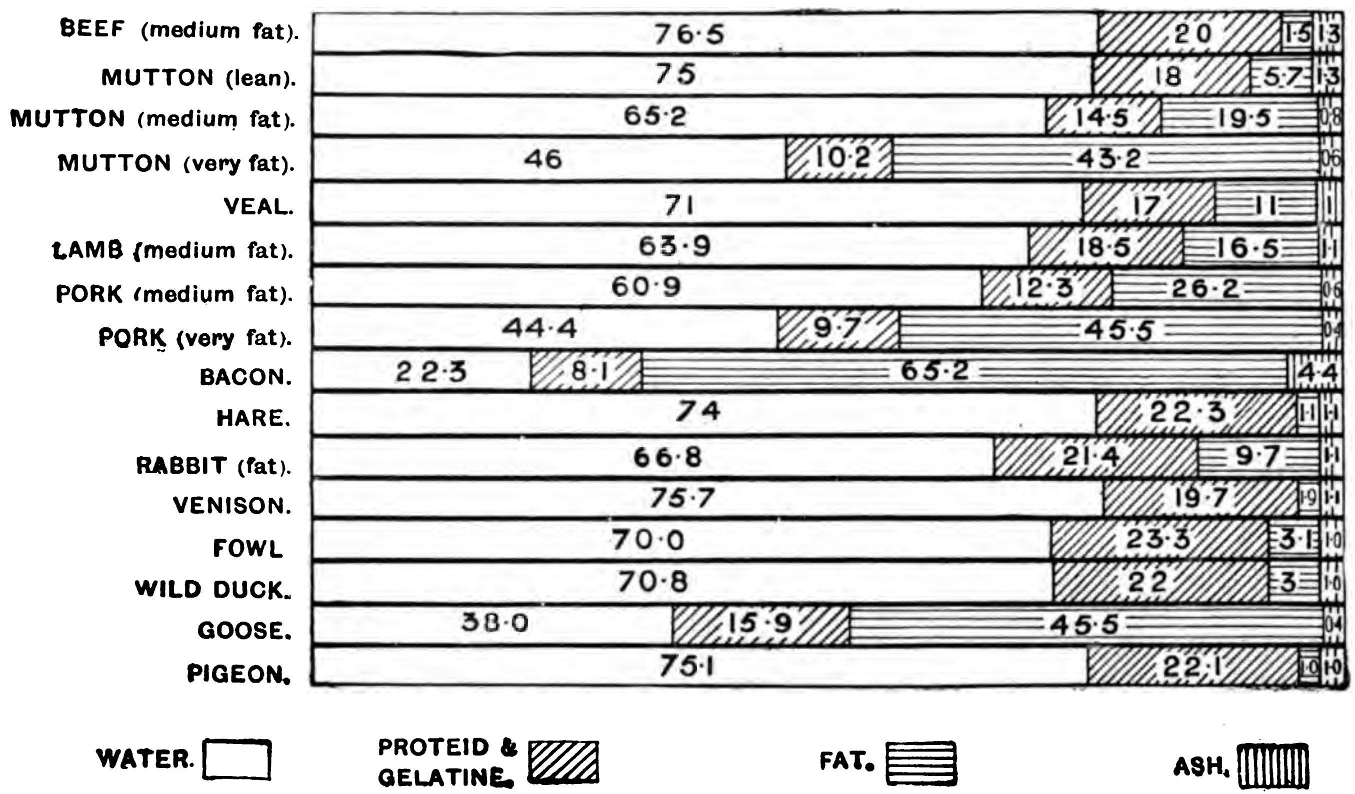
The **effects of fattening** are shown in the following table, in which the composition of lean, medium, and very fat beef are stated in round numbers:

	Water.	*Nitrogenous Matter.*[1]	*Fat.*	*Ash.*
Lean.. ..	76·5	21	1·5	1
Medium ..	73	20·5	5·5	1
Very fat ..	53	17	29	1

The chief points to note in this table are: (1) The large amount of water which meat contains. About three-quarters of the total weight of meat is made up of water, or, stated otherwise, 1 pound of meat contains ¾ pound water and ¼ pound of nutriment. It has been already pointed out that the flesh of young animals is relatively richest in water. (2) The relation between water and fat. The more there is of the latter present, the less there is of the former; in other words, when fat is deposited in a muscle, it replaces water, and not proteid, and so the gain in nutritive value is an absolute one, and is not attained at the expense of a loss of nitrogenous constituents. The above analyses refer especially to beef; the composition of the other commoner sorts of meat and some varieties of game may be graphically represented as follows:[2]

[1] 'Nitrogenous matter' is the figure obtained by multiplying the amount of nitrogen in 100 parts by 6·25; *i.e.*, it is assumed that it is all proteid. In reality 15 per cent. of the total nitrogen is present in the form of extractives, the amount of which can be calculated by multiplying their nitrogen by 3·12 (Stutzer's factor).

[2] Most of the analyses from which the diagram is constructed are by König and Stutzer. The analysis of lamb is from Atwater, that of bacon from Church.


BEEF (medium fat).
MUTTON (lean).
MUTTON (medium fat).
MUTTON (very fat).
VEAL.
LAMB (medium fat).
PORK (medium fat).
PORK (very fat).
BACON.
HARE.
RABBIT (fat).
VENISON.
FOWL
WILD DUCK.
GOOSE.
PIGEON.
76·5
20
1·5
1·3
75
18
5·7
1·3
65·2
14·5
19·5
0·8
46
10·2
43·2
0·6
71
17
11
1
63·9
18·5
16·5
1·1
60·9
12·3
26·2
0·6
44·4
9·7
45·5
0·4
22·3
8·1
65·2
4·4
74
22·3
1·1
1·1
66·8
21·4
9·7
1·1
75·7
19·7
1·9
1·1
70·0
23·3
3·1
1·0
70·8
22
3
1·0
38·0
15·9
45·5
0·4
75·1
22·1
1·0
1·0
WATER.
PROTEID & GELATINE.
FAT.
ASH.

It must be clearly realized that these results are merely approximative, and may vary considerably in different cases. Thus, in very young calves the amount of water in the flesh may be 80 instead of only 71 per cent. The relative proportions of gelatin and proteid also fluctuate considerably. The proportion of the former is highest in the flesh of young animals—hence the value of veal as a basis for soups—and is lowest in game. As regards the amount of the extractives, but few data are available, but the general impression that the red meats are richest in these constituents would appear to be erroneous. This is of some importance, as the belief has given rise to the practice of forbidding the red meats to patients who suffer from chronic disease of the kidneys (see also p. 506).

Hitherto we have been dealing with the structure and composition of meats in their raw state, and we must now direct our attention to the changes which are effected in them by **cooking**. The full consideration of this subject may be conveniently deferred to another chapter (Chapter XXII.), but at present one may note that the general effect of cooking on the *structure* of meat is (1) to loosen the fibres by converting the connective tissue which holds them together into gelatin, and (2) to remove some of the fat, the exact proportion depending on its melting-point, and being higher in cake-fed than in pasture-reared animals.

The chief effect of cooking on the chemical composition of meat is to diminish the amount of water which it contains. This results, curiously enough, even when the meat is cooked by boiling. The result is important, for it means a very considerable increase in the nutritive value of cooked, as compared with raw, meat, a result which is the very reverse of that which follows the cooking of vegetables (p. 386). In consequence of this **loss of water**, an ordinary plateful of cooked meat, weighing 4 ounces, may be regarded as equivalent to 5 ounces of raw meat. Another effect of cooking on the chemical composition of meat is the removal of part of the extractives. This is most marked when boiling is the method employed, but it also occurs to a considerable extent even in roasting. Some of the salts are also dissolved out by boiling, and I have already referred to the fact that cooking removes some fat as well. These general effects of cooking are illustrated in the following analyses by König of the same piece of meat before and after cooking:

	Water.	Nitrogenous Matter.	Fat.	Extractives.	Mineral Matter.
Beef: raw ..	70·88	22·51	4·52	0·86	1·23
boiled ..	56·82	34·13	7·50	0·40	1·15
roasted ..	55·39	34·23	8·21	0·72	1·45
Veal cutlets:					
raw.. ..	71·55	20·24	6·38	0·68	1·15
roasted ..	57·59	29·00	11·95	0·03	1·43

The following results were got by Tankard.[1] They represent the composition of various kinds of meat cut from the cold roast joint, and wholly edible. They include such a proportion of fat as would be commonly helped and eaten with the lean, but are exclusive of skin, gravy, and dripping:

	Mutton.	Lamb	Beef.	Veal.	Pork.	Duck.	Fowl.
Water (dried at 100° C.)	39·76	59·89	45·63	51·88	44·90	64·13	67·40
Fat (ether ext.)	26·80	11·95	24·21	11·39	19·67	6·06	6·68
Proteids (N x 6·3) ..	29·04	24·69	26·50	32·19	32·63	27·12	24·26
Ash	1·93	1·63	1·21	1·57	1·86	2·04	1·37
	97·53	98·16	97·55	97·03	99·06	99·35	99·71

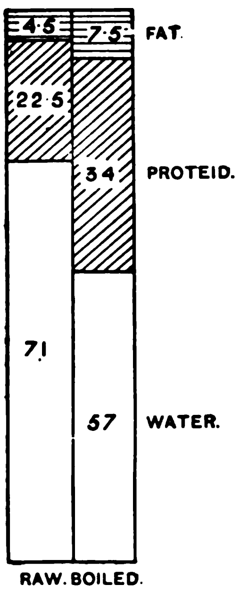


FIG. 6.—COMPARATIVE COMPOSITION OF RAW AND BOILED BEEF.

Taking König's figures, the composition of raw and boiled beef may be graphically compared as in Fig. 6.

2. DIGESTIBILITY AND ABSORPTION OF MEAT.

All solid foods are digested in the stomach in a physical sense; that is to say, they are reduced to a fluid or pulp, in which condition alone they are able to pass on into the intestine. But meat is a food the main share in the *chemical* digestion of which also falls to the lot of the stomach; that is to say, its chief nutritive constituent (proteid) is there got into a form fit for absorption. Now, it may be laid down as a rule that the greater the extent to which the chemical digestion of a food goes on in the stomach, the easier does its mechanical digestion prove. Hence, although meat makes considerable demands on the gastric juice, it does not throw any great strain on the mechanical resources of

[1] Allen's 'Commercial Organic Analysis,' iv. 269, second edition, 1898.

the stomach, and for that reason it must be regarded as among the more easily digested of the solid foods.

The first change which one observes during the **digestion of meat** is that the fibres swell up and become softened; their colour then changes to a grayish-yellow; they fall apart, and the mass becomes pulpy. Last of all, the individual fibres split up either into longitudinal threads or transversely into discs. It will be evident that the ease with which these changes can occur must depend on many conditions. The harder and denser the connective tissue which holds together the fibres, the less readily will they separate, and the greater the amount of fat between the fibres, the less readily can the gastric juice act upon the latter, hence the indigestibility of tough and fat meats. The longer and thicker the individual fibres, the more slowly are they split up; hence the improvement in the digestibility of tough meat which results from breaking up the fibres by pounding the meat across its cut ends. The **influence of cooking** also is of great importance. It has been found by experiments on man[1] that 3½ ounces (a small helping) of beef disappears completely from the stomach in the following times, depending on the method by which it has been cooked:

Raw	2 hours.
Half boiled	2½ ,,
Wholly boiled	3 ,,
Half roasted	3 ,,
Wholly roasted	4 ,,

Artificial experiments outside the body have confirmed these results. Popoff[2] found that the proportions digested in a given time were as follows:

Raw	100 parts.
Boiled	83·4 ,,
Smoked	71 ,,
Boiled and smoked ..	60·6 ,,

Stutzer[3] found that, of 100 parts, there is dissolved in half an hour:

	Raw.	*Boiled.*
By weakly acid juice	89·2 per cent.	38·7 per cent.
By normal juice	96·9 ,,	79·3 ,,

Similar experiments by Chittenden and Cummins[4] confirm these conclusions, and the only experiments with which I am acquainted which resulted differently were some by Uffelmann[5] on a boy with a gastric fistula, in whom it was found that raw meat was digested

[1] Jessen, *Zeit. für Biologie*, xix. 129, 1883.
[2] Popoff *Zeit. für Physiol. Chemie*, xiv. 524, 1890.
[3] Weyl's 'Handbuch der Hygiene,' Bd. iii., p. 216.
[4] *American Chemical Journal*, vi. 318, 1884-85.
[5] *Deut. Archiv. für Klin. Med.*, xx. 535, 1877.

rather more slowly than roast, although the fibres of the latter fell apart more rapidly.

On the whole, one may conclude that most forms of cooking tend to lessen the digestibility of meat in the stomach, a conclusion which applies, almost without exception, to *all* forms of animal food, but is quite the reverse of true as regards vegetable foods (see Chapter X.).

In accordance with these experimental results one finds that raw, or at all events much underdone, meat is a form of food which patients with very weak stomachs can digest more easily than most other forms of nourishment. The best method of preparing such meat is by scraping a piece of tender juicy steak with a blunt instrument in a direction parallel to the course of the fibres. This separates out the fibres from the enclosing connective tissue, and leaves the latter behind. The fibres form a pulp which can be seasoned with celery, salt, and a little pepper, and served either as a sandwich or stirred into broth. In what is known as the **Salisbury cure** another method of administration is adopted. The meat is chopped very thoroughly, all visible connective tissue and gristle being removed, and it is then made into little cakes ½ to 1 inch in thickness, and of 3 or 4 inches diameter. These are placed in a clean frying-pan, strongly heated, but without either water or grease. When one surface of the cakes is seared they are turned over and the other heated similarly. They are then covered and set on the side of the fire till the red colour of the meat has been changed to a drab. They are finally seasoned with a little fresh butter and salt, and are ready to be served.

As regards the **relative digestibility of the different kinds of meat**, there are but few exact data available. There is a general impression that **mutton** is more easily digested than beef, which some have attributed to the finer fibres and looser connective tissue of the former. Jessen, however, found that 3½ ounces of raw mutton were digested in precisely the same time as an equal weight of beef; while the experiments of Chittenden and Cummins showed that the digestibility of mutton, outside the body at least, was *inferior* to that of beef (92 as compared to 100). They admit, however, that the results varied greatly in different samples owing to age and other conditions. There can be no doubt that mutton fat, especially when hot, is particularly apt to prove irritating to the stomachs of some persons, and in them the eating of such articles as mutton pies or Irish stews is prone to be followed by an attack of acute gastric catarrh.

Veal is believed to be somewhat difficult of digestion, a belief

which is confirmed by experiment, for it required two and a half hours for its digestion, as compared with two hours for beef (Jessen). The difficulty of digesting veal is somewhat surprising, for the connective tissue, though abundant, is very easily changed into gelatin. It is believed by some that the explanation is to be found in the ease with which the fibres of veal elude the teeth on mastication; the comparatively insipid character of veal may also be a contributive cause, for such foods do not tend to excite a free flow of gastric juice.

The comparative indigestibility of **pork** is shown by the fact that 3½ ounces of it required three hours for their complete digestion, as compared with two hours for beef. The difficulty here is fully accounted for by the large accumulation of fat between the fibres. On the other hand, the fat of **bacon** seems to be in a granular form, which is not difficult to digest, and it can often be eaten with impunity by persons to whom other forms of fat are intolerable. For this reason bacon is an invaluable aid in feeding delicate children and diabetic or phthisical patients in whose diet the free use of fat is indicated.

The breast of **chickens and game** is amongst the most digestible forms of meat, but the leg muscles are often very tough. Very fat poultry should be avoided by the dyspeptic, as the fat of such birds is particularly apt to become rancid.

Lastly, it must be pointed out, in connection with the relative digestibility of different sorts of meat, that idiosyncrasy plays a very large part in the process. There are persons, for instance, whom mutton invariably makes ill, while they can eat beef with impunity, and others who can take mutton, but cannot touch beef. No explanation of such cases can be given.

The **absorption of meat** has already been referred to (Plate II.). It was shown that only about 5 per cent. of the organic matter in meat fails to enter the blood, and that as the result of this meat is a food which leaves a very small residue in the intestine. This gives it a special value in some cases of intestinal disease.

3. Nutritive Value and Economy of Meat.

The principal nutritive constituent of meat is proteid, and it is as a compact and easily digested source of this that meat is chiefly of value. Meat is thus one of the best sources of building material for the body. We have also seen that proteid is characterized by the rapidity with which it can be broken down by the cells with the

liberation of heat, or, in other words, that it is a 'quick fuel.' It is to this fact, probably, that meat owes the 'heating' qualities commonly ascribed to it, and for a similar reason its use should be restricted in hot weather. The use which is made of meat in training has been justified on the same grounds (p. 40). Another characteristic of proteid is that it seems to exert a stimulating effect on the cells and on the body generally, and the feeling of well-being which follows a meat meal may be put down to this cause. In savages who are unaccustomed to meat the free consumption of it is said sometimes to produce a nervous excitement amounting almost to intoxication. For this reason, too, the presence of much meat in the diet seems to act as an exciter of the animal passions, and an eminent authority[1] has advised that in the treatment of cases in which such propensities require to be kept in check one should 'avoid flesh, as the incarnation of rampant, uncontrollable force.'

Meat is one of the few articles of diet on which life can be supported alone for an almost indefinite time. It cannot, however, be regarded as constituting in itself anything like a perfect food. It is relatively much too rich in nitrogen and too poor in carbon. It would require about 4½ pounds of it a day to supply the energy required, and such a quantity would be apt to damage the digestion, besides overloading the blood with nitrogenous waste products.

The almost exclusive use of lean meat is the basis of the 'Salisbury cure,'[2] to which reference has already been made, and it has also been recommended as a means of treating some diseases of the skin—*e.g.*, psoriasis[3]—which have resisted the ordinary remedies. The use of meat in such diseases as diabetes, gout, obesity, will be dealt with in another chapter.

The relative nutritive value of different sorts of meat depends chiefly on the amount of fat they contain. Fat, as we have seen, replaces part of the water, and not the proteid, of the leaner meats, and thus the fat meats are better sources of fuel than the latter, while not inferior to them in building material. Apart from this, the nature of the extractives present may perhaps have some influence on general metabolism. Dr. Smith[4] tells us that Kean, the famous actor, used to adapt the kind of meat he ate to the part he had to play, choosing pork for tyrants, beef for murderers, and mutton for lovers. This may seem far-fetched, but it may indicate that there are subtle differences in the different kinds of meat which chemistry

[1] Clouston, 'Insanity,' p. 520.
[2] 'The Relation of Alimentation and Disease'; Salisbury, New York, 1895.
[3] Parkes, *Lancet*, 1874, i., p. 722.
[4] *Food*, p. 52.

does not enable us to detect, but which are yet not without influence upon the body.

From an economic point of view **meat is a dear food**. This is clearly shown in Plate III., and holds good whether one regards meat merely as a yielder of energy or as a source of building material. The costliness of it, however, can be considerably diminished by selecting the cheaper 'cuts,' which are equal in nutritive value to the dearer kinds, though inferior in tenderness and flavour. The question of waste from bone, etc., must also be considered. Thus, in the case of mutton and pork, the leg contains relatively less bone than the shoulder, and in beef there is a much larger proportion of bone in the shin than in the round, and of these the least bony parts will be the most economical from a nutritive point of view. Much, too, can be done to diminish the cost by the use of the cheap **frozen meats** which are now imported. These are equal in nutritive value to fresh meat, and are only slightly inferior to the latter in keeping qualities. They are not drier than ordinary meats, as is often stated, for chemical analysis shows that the proportion of water is only 10 per cent. less than that of fresh meat, while their digestibility is precisely the same.[1] From an economic point of view, also, it must be regretted that there exists a prejudice against the use of **horse-flesh** as a substitute for ordinary meat. It is well flavoured—indeed, a Châteaubriand steak is said by connoisseurs to be best when made of horseflesh—and any toughness can be overcome by suitable cooking. In Paris the use of horseflesh for human food is increasing every year, and one can only hope the poorer classes in this country may ultimately take to it too. Indeed, it is stated to be already largely used in the manufacture of smoked meats.

There is also a prejudice against the use as human food of **the flesh of animals which have died of disease**. This, again, can hardly be justified on grounds either of science or experience. The shepherds of Scotland have long used 'braxy' mutton—*i.e.*, the flesh of sheep which have died of various diseases—and I am not aware that it has ever been known to produce any harmful results. A French observer[2] has recently put the matter to the test of experiment. He took the flesh of animals which had died of various diseases, including that of a mad dog !), cooked it in various ways, and gave it to people who were ignorant both of its nature and

[1] Gautier, 'Frozen Meat as an Article of Diet' (abstract in *Edinburgh Medical Journal*, August, 1897).

[2] Decroix, 'Recherches Expérimentales sur la Viande de Cheval et sur les Viandes Insalubres'; Paris, 1885.

source. No bad effects followed its consumption. He concludes, fairly enough, that the use of diseased meat is harmless provided it be properly cooked, and that the overstrict inspection of slaughter-houses may do more harm by rendering meat dear, and therefore inaccessible to the poor, than it does good by preventing disease.

There remain to be discussed some parts of animals, other than the flesh, which are sometimes used for foods, and which are usually classed together under the rather unsavoury title of **offal**. These comprise such articles as the kidneys, liver, sweetbreads, blood, heart, lungs, and other internal organs, and together make up about one-third of the total weight of the carcase.

The **general composition** of these articles is shown in the following table:

COMPOSITION OF OFFAL.

	Water.	Nitrogenous Matter.[1]	Fat.	Carbo-hydrates.	Ash.
Kidney (ox)	76·7	16·9	4·8	0·4	1·2
,, (sheep)	78·7	16·8	3·2	—	1·3
Liver (ox)	71·2	20·7	4·5	1·5	1·6
,, (sheep	61·2	23·1	9·0	5·0	1·7
Heart (ox)	62·6	16·0	20·4	—	1·0
,, (sheep)	69·5	17·0	12·6	—	0·9
Lung (ox)	79·7	16·1	3·2	—	1·0
,, (sheep)	75·9	20·2	2·8	—	1·2
Sweetbreads	70·9	16·8	12·1	—	1·6
Blood	80·8	18·1	0·2	—	0·85
Tripe	74·6	16·4	8·5	—	0·5
Tongue (ox) fresh	63·8	17·1	18·1	—	1·0
,, smoked and salted	35·7	24·3	31·6	—	8·5
Brain	80·6	8·8	9·3	—	1·1

It will be observed that, from the chemical point of view, they are substances of considerable nutritive value, and as their price is also for the most part low, as compared with that of ordinary meat, they must be regarded as important sources of proteid in the diet.

The **liver and kidneys** resemble one another in being compact, solid organs, containing but little connective tissue. This physical property renders them somewhat difficult of digestion, unless they have either been minced before cooking (as the liver is, for instance, in making a haggis), or are rather carefully chewed. Chemically, both consist chiefly of proteid along with a small amount of fat. The proteid which they contain is quite different from that of ordinary meat, consisting as it does to a large extent of nucleo-proteid, which yields nuclein on digestion. Now, it has recently

[1] N × 6·25.

been proved that nuclein is an important source of uric acid, and for that reason it may be well for gouty persons to avoid the dietetic use of the articles under consideration.

The **heart** resembles ordinary meat very closely as far as chemical composition is concerned, but differs from it in being of a denser structure, and therefore of less digestibility. For healthy persons, however, it is an excellent and economical food, and might with advantage be made larger use of than at present it is.

It seems natural to suppose that **blood** must be a very valuable food. 'The blood is the life,' and it would seem as if blood must represent in itself the essence of strength and energy. But it is not so; and the misconception proceeds from a neglect of the fact that blood is not *in itself* the food of the tissues, but is merely the vehicle by means of which nourishment is carried from the intestines to the places where it is wanted in the body. One might as well expect a spoon to be of nutritive value because it conveys food from the plate to the mouth. Two French experimenters[1] found that blood when administered to dogs, even in the liberal measure of 2 pounds daily, did not suffice to maintain the life of the animals for more than a month. This is due in part to the fact that blood is a dilute fluid, for, of every 100 parts of it, from 78 to 82 consist of water. Blood, in fact, from a chemical point of view, is not so much thicker than water after all. In the solids there is plenty of proteid, but the other nutritive constituents of food—fat and carbohydrates—are only represented in quite inappreciable amount. In addition to this, the red colouring matter (hæmoglobin) which makes up the larger part of the proteid is a substance which is very far from being completely absorbed.[2] There are, thus, no chemical considerations which can outweigh the natural repugnance which most persons feel to the eating of blood; and though it may be used without harm, if also without much benefit, in the form of black-puddings and such-like, there is no reason to advocate its habitual consumption, much less its employment in the feeding of the sick; and this is true also of the use of blood as a source of iron.[3]

The **lungs**, from the fact that the air which they contain enables them to float in water, are popularly spoken of as the 'lights.' They are sometimes eaten, but cannot be regarded as a really good form of food. Their chemical composition furnishes the reason.

[1] Payen and Magendie.
[2] See Gherardini, *Rev. des Sciences Méd.*, xxxix. 88, 1892; and Kobert, *St. Petersburger Med. Wochenschrift*, 1891 p. 439.
[3] See Starck, *Deut. Med. Woch.*, December 22, 1898.

The lungs are largely composed of an elastic material belonging to the group of albuminoids, and only imperfectly capable of digestion, besides being useless as building matter in the body.

Under the term **sweetbread** butchers include at least two distinct organs. The 'throat sweetbread' is known to anatomists as the thymus gland; the 'stomach sweetbread' is the pancreas. The thymus of the calf is the one most frequently met with in the market. Both glands are cellular organs, held together by a loose and delicate connective tissue. From the nature of the latter they are easily dissolved in the stomach, and rank amongst the most digestible of animal foods, 9 ounces of sweetbread being completely disposed of by a healthy stomach in two and three-quarter hours, while a similar weight of beefsteak demands at least four and a half hours for its complete digestion.[1] The cells of these organs are chiefly composed of nucleo-proteid, and for that reason, as has already been pointed out in the case of the liver and kidney, sweetbreads may prove harmful to the gouty.

Tripe is the name applied to the stomach and intestines of the ox after being cleaned and boiled. It contains a large amount of connective tissue, readily changed into gelatin on boiling, and so rendering the fibres easily digested. It contains fat in considerable amount, but not diffused through the muscular part. I am not acquainted with any experiments on its rate of digestion in the stomach, but in the intestine it has been found to be as completely absorbed as beef.[2] Unfortunately, the absence of extractives causes tripe to be rather deficient in flavour, but otherwise it must be regarded as a valuable and easily-digested food.

The **brain** of animals is only occasionally eaten as food. Brain consists largely of a fatty material containing cholesterin and lecithin, the latter being comparatively rich in phosphorus. In the stomach, owing to its soft consistency, brain is more rapidly digested than any other animal food, but, unfortunately, it is very imperfectly absorbed, 43 per cent. of it reappearing in the fæces (*vide infra*). In spite, therefore, of its easy digestion, it cannot be regarded as a valuable food for invalids, nor is it in any sense specially apt to 'make brains.' 'Some fancy,' says an ancient writer,[3] 'that Rabbits' Brains weaken the Memory, because this animal cannot for a moment after retain in mind the Foils laid for her and that she had just

[1] Penzoldt, *Deut. Archiv. für Klin. Med.*, li. 535, 1893.
[2] Solomin, *Arch. für Hygiene*, xxvii. 176, 1896.
[3] Lemery, 1745.

escaped; but this conjecture, being grounded upon a weak Foundation, I shall not stop here and go about to confute it.' The idea that brain can in any way contribute to the nourishment of brain is grounded on an equally 'weak foundation.'

The **comparative absorption** of some of the articles of which we have been speaking, as found by experiment, is as follows:

Voit[1] states that

100 parts of	dry	liver	yield	5	parts of	dry fæces.
"	"	lung	"	8	"	"
"	"	thymus	"	7	"	"
"	"	brain	"	43	"	"

Emil Bergeat[2] found the loss of nitrogen in the dog to be:

In meat	.. .. ..	2·1 per cent.
In thymus	.. .. ..	3·2 "
In liver	.. .. ..	3·3 "
In lung	.. .. ..	4·2 "
In brain	.. .. ..	13·9 "

The average composition of some **potted meats** is represented in the following table (from König):

	Water.	Nitrogenous Matter.	N-free Extractives.	Fat.	Ash.	Salt.
Foie gras ..	46·04	14·59	2·67	33·59	3·11	0·22
Potted beef ..	32·81	17·17	3·36	44·63	2·03	
" ham ..	25·57	16·88	—	50·88	6·78	5·72
" tongue ..	41·52	18·46	0·46	32·85	6·71	5·98

These substances require no special description.

Sausages are preparations of very uncertain composition. It has been remarked of them with some truth that they are like life; for you never know what is in them till you have been through them. In this country they are usually made of uncooked meat, but various vegetable substances, especially bread, are frequently added as well, and the vegetable matter is not infrequently disguised by the addition of colouring materials. Seasonings of various sorts also enter into their composition. The following analyses by Allen[3] represent the composition of some typical kinds:

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1 *Zeit. für Biologie*, xxv. 232, 1889.
2 *Ibid.*, xxiv. 120, 1888.
3 'Commercial Organic Analysis,' second edition, vol. iv., p. 280.

COMPOSITION OF SAUSAGES.

Variety.	Price per lb.	Water.	Fat.	Proteid.	Gristle, etc.	Starch.	Ash.
Pork	9d.	54·99	21·04	12·28	0·67	1·05	3·52
'Cambridge' pork ..	9d.	51·54	29·72	9·45	0·72	2·20	3·47
Mutton ..	1s.	55·58	30·51	1·89	3·11	3·90	2·50
German ..	8d.	46·54	17·87	16·38	1·13	15·00	4·47
Polony ..	10d.	45·57	32·66	17·26	0·54	2·30	2·80

As sources of proteid, they are certainly not more economical than ordinary meat.

The use of bones as food will be dealt with in the next chapter.

CHAPTER V

JELLIES—FISH

THE chemical basis of jellies is **gelatin.** Gelatin is derived from collagen, which is the chief constituent of connective tissues, and is converted into gelatin by boiling. All forms of connective tissue can be made to yield gelatin by suitable treatment. Glue is a crude form of the substance obtained from hide-clippings, and ordinary commercial gelatin is simply a purified form derived from the same source. The connective tissues of young animals are especially rich in gelatin-yielding material. Veal, for example, contains 4 to 5 per cent. of connective tissue, and is therefore a favourite basis for the making of strong soups. Calves' feet (free from bone) yield 25 per cent. of gelatin on boiling and 11·3 per cent. of fat,[1] and have long been known as abundant yielders of a pure jelly. The purest form of all, however, is **isinglass**, a substance obtained from the swim-bladder of fish, especially of the sturgeon. Chemically it is not really richer than ordinary gelatin, as is shown in the following comparative analyses:[2]

	Ordinary Gelatin.	*Isinglass.*
Water	13·6	19·0
Albuminoid	84·2	77·4
Fat	0·1	1·6
Carbohydrate		
Ash	2·1	2·0
Full value per pound ..	1,570 Calories.	1,510 Calories.

The chief physical peculiarity of gelatin is its capability of dissolving in boiling water, and subsequently setting into a jelly on cooling. It is remarkable how weak a solution is capable of doing this. Even when as little as 1 per cent. is present the solution sets. The ordinary strength of which jellies are made is 1 ounce to the

[1] Uffelmann, 'Ueber Sparstoffe und deren Verwendung in der Kost der gesunden und Kranken,' *Wiener Klinik.*, Heft 7, Bd. 17, 1891.

[2] Atwater, 'Chemical Composition of American Food Materials,' Bulletin 28, United States Department of Agriculture.

quart, which is equivalent to a 2 per cent. solution, and from this one can realize how little gelatin there really is in ordinary jellies. I have found that 6 ounces (a large helping) of ordinary calf's-foot jelly contains $1\frac{3}{8}$ ounces of solid matter, of which less than $\frac{1}{2}$ ounce is gelatin, the remainder being chiefly sugar.

The **digestion of gelatin** in the stomach is a very easy process; indeed, in this respect it is hardly surpassed by any other food. Uffelmann found that, in a boy with a gastric fistula, complete peptonisation took place within an hour, but he does not state how much jelly was administered.

Gelatin has the advantage of fixing a good deal of acid in the process of digestion, and is thus of service in cases of hypersecretion of acid in the stomach. It seems also to belong to the 'peptogenic' substances—*i.e.*, those bodies which favour an abundant flow of gastric juice (see p. 398).

In estimating the **nutritive value of gelatin**, it is important to emphasise again what has been already mentioned, that gelatin is not a substance which is capable of building tissues, and is in no sense a true substitute for proteids. This has been attributed by Bunge to the fact that gelatin contains more oxygen and less carbon than proteids, and is thus, as it were, a stage on the way to their decomposition. As a source of heat and energy, it is equal to proteid or carbohydrate, 1 gramme yielding about 4·1 Calories.

It is as a sparer of proteid, however, that gelatin is chiefly of importance in the food. It is the most powerful **proteid-sparer** known, being able to save from destruction half its weight of proteid, or twice as much as is spared by an equal quantity of carbohydrate. In estimating its value in this direction as an ordinary food, it must be remembered that even persons who live on a mainly animal diet do not consume more than one-tenth to one-eighth of their total nitrogen in the form of gelatin, and that probably not more than 25 to 30 grammes of the latter substance can conveniently be taken in a day. This restricts its usefulness considerably, for even a quart of jelly would only be able to spare the proteid in $2\frac{1}{2}$ ounces of meat; and assuming that 25 grammes of gelatin were contained in the diet, this would only effect a saving of 35 grammes of meat ($1\frac{1}{4}$ ounces) and 40 grammes of bread ($1\frac{1}{2}$ ounces). An ordinary slice of a 4-pound loaf weighs $2\frac{1}{2}$ ounces. One can realize from this that the usefulness of gelatin as a proteid-sparer in fevers and diabetes is of limited range. As a pleasant addition to the diet of convalescence, however, jellies are of service, but their nutritive

value depends mainly on the sugar which they contain, and not on the gelatin. Their value in acid dyspepsia has already been mentioned.

The **cost of gelatin** depends entirely on the source from which it is derived, and it may be said at once that for ordinary purposes commercial gelatin (*e.g.*, Nelson's or Cox's) is the most economical. It has been calculated that it costs sixteen times as much to prepare jelly from calves' feet as to use commercial gelatin for the purpose (Thudichum). Isinglass is an even costlier source, a quart of jelly made of commercial gelatin costing about 6d., whereas if isinglass be used it will cost about 1s. 9d., and it does not even seem to be altogether true that the latter goes further and sets better. The same is true of soups, for it is cheaper to add 7 or 10 grammes of gelatin to ordinary stock if one wants a strong soup than to get the gelatin from boiling up veal. Bones are only a cheap source of it in so far as they cannot be used for any other purpose. The composition of **bones** is about as follows:

Water	5 to 50 per cent.
Gelatin substance	15 to 50 ,,
Fat	½ to 20 ,,
Ash	20 to 70 ,,

When boiled in the usual way they yield from 1½ to 7 per cent. of their weight, chiefly in the form of fat. When broken up and treated in a Papin's digester the yield is greater, 3 pounds yielding (according to Smith) as much nitrogen as can be got from 7 pounds of meat, and as much carbon as is yielded by 1 pound under similar treatment. In spite of this, Forster concluded from his experiments on the subject that it is cheaper to use commercial gelatin than to buy bones specially to produce it. Gelatin, therefore, is only a cheap addition to poor diets in so far as it can be obtained from many materials which would otherwise be wasted, and ordinary jellies can only be regarded as dear foods, for a shilling spent on the 'calf's-foot jelly' of the shops yields only 470 Calories of energy, and no building material at all.

FISH.[1]

1. **Chemical Composition.**—Proteid and fat are the chief nutritive

[1] In preparing this section the writer has derived much help from the following publications: 'The Chemical Composition and Nutritive Values of Food Fishes and Aquatic Vertebrates,' by W. O. Atwater, Ph.D., Washington, 1891 (abstract from Report of United States Commissioner of Fish and Fisheries, 1888); and 'Fish as Food,' United States Department of Agriculture, Farmers' Bulletin 85, 1898, by C. F. Langworthy, Ph.D.

constituents found in fish, just as they are in meat. According to the relative proportions of these ingredients present, fish may be conveniently divided into the two groups of 'fat' and 'lean,' or, more exactly, thus:

(*a*) Fish with more than 5 per cent. of fat.
Examples: Eel (18 per cent.), salmon (12 per cent.), turbot (12 per cent.), herring (8 per cent.).
(*b*) Fish with from 2 to 5 per cent. of fat.
Examples: Halibut (2 up to even 10 per cent.), mackerel (2 up to 9 per cent.), mullet (about 2½ per cent.).
(*c*) Fish with less than 2 per cent. of fat.
Examples: Cod, haddock, whiting.

The exact **chemical composition** of the commoner varieties of fish is shown in the following analyses by Miss Katherine Williams,[1] the results having reference to the fish as prepared for the table:

ANALYSIS OF COOKED (BOILED) FISH AS SERVED AT TABLE.

Fish.	Part analyzed.	Waste (Bones, etc.)	Gelatin.	Water.	Nutrients.
Herrings ..	Whole	11·74	0·63	52·99	34·54
Salt herrings	Flesh	—	—	46·03	53·97
Sprats ..	Whole	17·90	0·90	61·50	19·70
Sardines ..	,, ...	4·91	—	42·17	52·92
Salmon ..	Section	5·99	0·53	61·06	32·02
Trout ..	Whole	8·23	0·55	67·12	24·10
Eels ..	Heads removed ..	11·66	1·09	53·29	33·96
Mackerel ..	Whole	10·51	0·25	65·21	24·03
Cod.. ..	Section	15·99	0·43	63·78	19·79
Salt cod ..	,, ...	6·13	0·33	67·68	25·86
Haddock ..	Whole	35·10	0·80	46·46	17·64
Whiting ..	,, ...	21·50	0·86	61·29	16·35
Turbot ..	Anterior and head	31·20	0·59	53·09	15·12
Halibut ..	Section	6·84	0·03	69·35	23·78
Plaice ..	Flesh	—	—	79·86	20·14
Soles ..	Whole	22·02	0·74	61·18	16·06
Lemon soles	,, ...	26·17	1·42	56·56	15·85
Oysters ..	Shell contents ..	—	—	77·71	22·29
Smelts ..	Whole	18·86	0·38	65·20	15·56
Red mullet	,, ...	24·28	2·41	50·05	23·26
Roach ..	,, ...	24·36	0·65	56·52	18·46
Gurnet ..	,, ...	46·30	0·65	39·13	13·92
Tunny ..	Flesh from section	—	—	63·49	36·51
Hake ..	Section	7·84	0·26	78·01	13·89
John Dory	Whole	20·91	0·98	60·82	17·29
Brill ..	Section	8·19	0·19	57·49	34·13

[1] *Journal of Chemical Society*, lxxi. 649.

ANALYSIS OF FLESH OF COOKED FISH

Fish.	Water in Flesh.	Reducing Substances in Dry Matter as Glucose.	Ash in Dry Substance.	Solids in Dry Substance. N.	Fat.	Proteid.
Herrings	60·54	—	5·56	11·11	25·25	67·07
Salt herrings ..	46·03	17·59	19·69	7·12	21·90	38·88
Sprats	75·77	9·88	6·42	9·26	27·37	57·94
Sardines	44·35	—	12·03	8·54	33·49	55·44
Salmon	65·32	14·89	4·94	10·70	29·43	56·65
Trout	73·58	4·68	6·60	11·96	8·84	80·00
Eels	61·08	8·91	2·11	7·36	44·68	42·88
Mackerel	73·13	13·93	4·07	10·46	25·73	62·32
Cod	76·32	6·67	3·31	15·30	1·15	91·55
Salt cod	72·35	7·14	14·26	12·41	0·94	76·06
Haddock	72·37	13·15	3·28	13·11	1·29	79·57
Whiting	78·78	17·54	1·92	13·28	1·86	79·55
Turbot	77·84	11·81	2·41	13·76	4·75	84·71
Halibut	74·46	—	4·11	13·32	15·81	79·67
Plaice	76·86	11·56	4·06	13·02	9·84	75·16
Soles	79·20	11·87	3·47	14·00	1·71	86·71
Lemon soles ..	78·11	14·80	4·42	11·04	12·96	69·88
Oysters	77·71	18·32	12·16	11·85	7·77	65·42
Smelts	80·73	2·17	4·73	11·61	9·76	82·59
Red mullet ..	68·26	9·79	5·43	11·59	24·52	66·26
Roach	75·37	6·28	1·08	13·03	15·03	79·14
Gurnet	73·77	14·77	3·53	14·24	1·81	89·16
Tunny	63·49	—	5·52	10·55	30·68	66·08
Hake	84·88	13·64	3·90	12·86	5·67	81·36
John Dory ..	77·89	14·29	2·06	13·32	8·52	79·53
Brill	62·74	—	4·42	15·49	1·62	93·95

To these may be added some recent analyses of preserved fish and of sardines in oil:

PRESERVED FISH.

	Water.	*Nitrogenous Matter.*	*Fat.*	*Ash.*	*Salt.*
Dried cod ..	16·16	81·54	0·74	1·56	
Salt mackerel ..	44·45	19·17	22·43	13·82	11·42
„ herring ..	46·23	18·90	16·89	16·41	14·47
Smoked herring	69·49	21·12	8·51	1·24	

SARDINES IN OIL.[1]

Source.	*Water.*	*Fat.*	*Proteid.*	*Ash.*
Sicily	50·16	12·68	4·30	7·51
Tunis	50·36	13·07	4·07	7·85
Sardinia	40·66	23·75	3·83	8·98

Some points in these analyses are deserving of comment. The first thing to notice is the large amount of **waste matter**, in the form of skin, bones, etc., which fish contains. In fish, as sold, the waste may amount to fully 70 per cent., while even in fish as served at table it may be as high as 35 per cent. Another noteworthy point

[1] *Journal of Chemical Society*, vol. lxxii., part ii., p. 335.

is the comparatively large amount of water in the flesh of the leaner varieties of fish—considerably more than one finds in lean meat. Lastly, the relative proportions of the nitrogenous constituents are different from those in meat, fish containing more gelatin (about four to three in meat) and less extractives. Their greater richness in gelatin-yielding substance causes fish to lose more on boiling than meat does, and is one reason why boiling is by no means the best method of cooking fish (see p. 381). Their poverty in extractives is the cause of the lack of flavour in fish as compared with meat, and makes a fish diet apt to prove monotonous.

2. **Digestibility of Fish.**—*Artificial experiments* outside the body on the digestibility of fish have yielded rather discordant results. Popoff[1] obtained the rather surprising result that fat fish are more easily digested than lean; while 'smoking' actually increased the rate of digestion, prolonged cooking, on the other hand, rendering it slower. He gives the following table of the relative quantities digested in a given time:

Meat, raw	100
,, boiled	83
,, smoked	71
Eel, raw	71
,, boiled	68
,, smoked	91
Sole, raw	66·8
,, boiled	60·6
,, smoked	106·1

Chittenden and Cummins,[2] using a very similar method, got quite different results, for in their hands the fat fish proved less digestible than the lean, with the exception of mackerel, which was rather quickly dissolved. They found that the digestibility of fish in general was below that of beef, but several kinds were as easily digested as lamb or mutton. Cod, though containing very little fat, proved to be one of the most indigestible of the fishes they examined.

Penzoldt[3] employed a more natural method of experiment, fish being eaten in the usual way, and the time which elapsed before it had completely disappeared from the stomach noted. He found that 7 ounces of white fish were digested in two and a half to two and three-quarter hours, while a similar quantity of beef-steak requires three and a quarter hours. Salt fish was found to offer more resist-

[1] *Zeit. für Physiolog. Chem.*, xiv. 524, 1890.
[2] *American Chemical Journal*, vi. 318, 1884-85.
[3] *Deut. Archiv. für Klin. Med.*, li. 535, 1893.

ance to the action of the stomach, 7 ounces of salt herring requiring four hours for its digestion.

It must be admitted that the results of the last observer are more in harmony with those of everyday experience, which teaches that the lean fish are better borne by the stomach than the fat, and are apparently more easily digested than an equal quantity of meat. It is quite likely that fat interferes with natural digestion much more than with an imitation of the same process carried out *in vitro*: for not only does fat seem to arrest the natural secretion of gastric juice (p. 399), but the fat found in fish seems also to be particularly apt to become rancid and affect the stomach injuriously in that way. That white fish should be more easily dissolved by the stomach than beef is only what one would expect from its shorter fibre. This is specially evident in such fish as the whiting, which on that account has been fancifully described as 'the chicken of the sea,' and is frequently recommended, and probably with reason, to the dyspeptic and convalescent. Cod seems to be an exception among the white fish, having a rather coarse fibre, and the comparative indigestibility of it which Chittenden and Cummins found is by no means in contradiction with actual experience (Pavy). The slow solution of salt fish is fully explained by the hardening of the fibres which salting produces.

The **absorption of fish** in the intestine takes place fully as well as that of meat, about 95 per cent. of the total solids, 97 per cent. of the proteid, and 90 per cent. of the fat entering the blood (Langworthy). In virtue of this, fish ranks amongst the most fully absorbed of foods.

Nutritive Value of Fish.—The value of fish as a source of energy depends entirely on the amount of fat which it contains. The fat fish, such as salmon, are fully equal to moderately fat meat in this respect, while the lean fish, owing both to the absence of fat and the presence of more water, are of considerably lower nutritive value. It may be reckoned that 1½ pounds of cod or other white fish are only equal in nutritive value to 1 pound of lean beef.

As a source of building material, fish are somewhat inferior to lean meat, owing to the smaller amount of proteid which they contain. This statement applies more strongly to lean fish than to the fatter varieties. Owing to this smaller proportion of proteid, and in part also, in all probability, to their lesser richness in extractives, fish seem to be a less stimulating food than meat, and on that account are sometimes recommended as a substitute for the latter in the dietary of epileptics. For the same reasons, white

fish may sometimes be used with advantage instead of meat by sedentary persons, and in hot weather.

Two special qualities are erroneously attributed to a fish diet by popular fancy. I refer to the beliefs (1) that fish is specially valuable as a 'brain food,' (2) that it possesses aphrodisiac qualities.

The former of these opinions is grounded on the belief that fish is specially rich in phosphorus, and the way in which the fallacy became promulgated is of some interest. I have already referred to the dictum of Büchner, that without phosphorus thought is impossible (p. 42). The Swiss naturalist Agassiz, knowing this dictum, and being informed by the eminent chemist Dumas that fish contained much phosphorus, put two and two together, and concluded that fish would be specially good for the brain. But we have already seen that the aphorism of Büchner is not altogether true, and there is, further, no justification at all for the statement that fish is rich in phosphorus, and thus the belief that it is peculiarly adapted for the nourishment of the brain, being founded on a double fallacy, falls to the ground.

The second belief, which attributes to a fish diet special stimulating powers on the genetic faculty, has been widely entertained, and is advocated at some length by Brillat-Savarin in his well-known book. There is, however, no sufficient evidence in favour of this opinion, and it is contradicted, as Pereira has pointed out, by the fact that maritime populations are not specially prolific.

The impression that fish-eating produces a liability to certain diseases of the skin, and especially to leprosy, is founded on somewhat more scientific data, and has been adopted by some eminent authorities, but the discussion of the subject cannot be undertaken here. One practical outcome of this belief has been the abolition of fish from the dietary of the patients in the St. Louis Hospital for Skin Diseases in Paris.

Economic Value of Fish.—In the case of fish, even more than in that of most foods, the market-price is no indication of the true economic value. I have already illustrated this fact by pointing out (p. 16) that although such fishes as haddock and sole are of practically the same nutritive value, yet the price of the latter may be four or five times that of the former. On the other hand, it by no means follows that none of the dearer varieties of fish is worth the money. Salmon, for example, contains nearly three times as much nutriment as an equal weight of cod, and thus a pound of the former at 1s. 6d. may not really be any dearer than a pound of cod at 6d. The

amount of waste in fish is also of great importance from the economic standpoint. We have seen that the inedible parts of fish as purchased may amount in some cases to as much as 70 per cent. of the whole, and allowance must be made for this in calculating the real cost. For this reason it may be worth while to pay a rather high price for canned or tinned fish, for in these preparations almost the whole of the material paid for is in an edible form.

As a general rule, it may be said that the cheaper varieties of the fat fishes offer most nutriment for any given sum. Salted white fish probably rank next to these. It has been truly remarked by Dr. Smith[1] that the despised herring or bloater 'offers the largest amount of nutriment for a given sum of any animal food,' and two salt herrings contain as much animal proteid as need enter into the daily dietary of an ordinary working man.

The justice of these remarks is borne out by the following calculations, taken from several made by Langworthy,[2] English prices being substituted for American:

COMPARATIVE COSTS OF PROTEID AND ENERGY AS FURNISHED BY DIFFERENT KINDS OF FISH.

	Price per lb.	*Cost of Proteid per lb.*	*Cost of 1,000 Calories of Energy.*
	d.	s. d.	s. d.
Cod..	5	3 11	2 0½
Halibut	9	4 9	1 7
Salt cod	3½	1 10	0 11
Salt mackerel ..	5	2 10	0 5½
Tinned salmon ..	6	2 3½	0 6½
Round of beef ..	7	3 2½	0 8
Milk	3d. per quart.	3 9½	0 4½

The greater cheapness of the salt fish, and especially of those which are also fat, is at once manifest.

Of the 'offal' of fish, the ovary, or **roe**, is alone commonly eaten. The roe of the sturgeon, when highly salted, constitutes *caviare*, the best forms of which come from Astrachan. Good **caviare** should be of a grayish colour—not black—and one should be able to make out the separate eggs in it quite easily. It is packed in vessels made of lime wood, as it is very apt to take up foreign flavours, and of these lime wood is destitute. The composition of caviare—and approximately of all fish-roe—is as follows (Langworthy):

Water	38·1 per cent.
Proteid	30·0 ,,
Fat	19·7 ,,
Other non-nitrogenous matters ..	7·6 ,,
Mineral matter (including salt) ..	4·6 ,,
Fuel value per lb.	1,530 Calories.

[1] 'Foods,' p. 110. [2] 'Fish as Food,' p. 18.

The proteids contain a good deal of nuclein, the significance of which as an article of diet has already been mentioned (p. 71).

Three ounces of raw salted caviare are digested in about two hours.

The **milt** is the organ in male fish corresponding to the roe, and resembles the latter very closely in composition and nutritive value. The only patent food derived from fish with which I am acquainted is the preparation known as **Marvis.**[1] This consists of the flesh of white fish reduced to a dry powder, the characteristic flavour of the fresh fish being well retained. The substance consists almost entirely of proteid, and has undoubtedly a high nutritive value. It keeps well, and may be conveniently employed for making soups, etc.

The lobster, crab and other crustaceans; the molluscs, such as the oyster and mussel; and the turtle and frog amongst reptiles and amphibians, may conveniently be considered at this point.

The **lobster and crab** both consist of two distinct parts: the flesh, which is contained in the claws and tail; and the body, which is mainly made up of liver. The general composition of these parts is thus contrasted by Payen:

	Flesh.	*Body.*
Water	76·6	84·31
Proteid	19·17	12·14
Fat	1·17	1·14

König gives the composition of *potted lobster* as follows:

Water	51·33
Nitrogenous matter	14·87
Fat	24·86
Other non-nitrogenous matter	4·04
Ash	4·90
Salt	0·38

That of *tinned lobster* is (Langworthy):

Water	77·8
Proteid	18·1
Fat	1·1
Carbohydrates	0·6
Mineral matter	2·4

The composition of the crab is practically the same.

The flesh of the lobster and crab is rather indigestible, mainly on account of the density and coarseness of the fibres and the thickness of their walls. The use of vinegar helps to soften the fibres, besides neutralizing ammoniacal salts, which are apt to be present.

[1] Prepared by the Patent Fish Food Syndicate, Limited, Upper Greenock Station, Greenock, N B.

The body of these animals is also apt to disagree, not only from the fat which the liver contains, but also, apparently, from the occasional development in it of irritant poisons.

Three ounces of potted lobster require about two and a half hours for digestion in the stomach.

The **oyster** is the most typical and popular of the molluscs. Chemically it contains within itself representatives of all three nutritive constituents of the food:

AVERAGE COMPOSITION OF OYSTERS (Langworthy).

(Exclusive of Liquid.)

Water	88·3
Nitrogenous substances	6·1
Fat	1·4
Carbohydrates	3·3
Salts	1·9

The proportion of solid nutriment, however, is not large, three dozen moderate-sized oysters having only from 2¾ up to 5⅛ ounces of solids. It is probable, too, that the nitrogenous matter which they contain is not all in the form of proteid, but is partly present as other compounds of lower nutritive value.

Glycogen is the form in which carbohydrate is present in oysters. It is contained in the liver. Its presence renders oysters an unsuitable food in cases of diabetes in which a strict diet is being enforced.

The oyster is rightly regarded as an easily-digested food—at least, if taken raw. Three medium-sized oysters are entirely disposed of by the stomach in one and three-quarters hours. Cooking renders them tough and less easily digested.

The nutritive value of oysters is not high. A dozen Ostend oysters contain about 5 grammes of digestible proteid and 1⅛ grammes of fat. It would take fourteen of them to contain as much nourishment as one egg, and 223 to equal a pound of beef (Stutzer). One is therefore not surprised to hear of enormous quantities of oysters being occasionally consumed at a sitting. Brillat-Savarin relates that he was acquainted with a man who used to eat a gross of them at a time, and follow that up by a heavy dinner! They are also an extravagant form of food, for a given quantity of proteid costs about three times as much in the form of oysters as it does if purchased as beef.

In recent years oysters have to some extent fallen into disfavour, from the belief that they may be the means of conveying the in-

fection of typhoid fever. The belief is not unwarranted, for if oysters are grown in estuaries they might easily enough become infected with typhoid germs derived from sewage, and it has been found by artificial inoculation that typhoid bacilli thus introduced are capable of surviving in the body of the oyster for several days.[1] The risk, however, can be avoided by keeping the oysters alive for a day or two in salt water which is frequently changed. This washes them out and destroys the bacilli. Cooking effects the same object with greater certainty, but at the cost of diminished digestibility.

The 'greening' of oysters is another subject which has recently attracted a good deal of attention. From their investigations into the cause of this phenomenon, Herdman and Boyce have concluded that there are several kinds of greening, some of which, such as that found in the green Marennes oysters and in those of several rivers on the Essex coast, are healthy; while in others, such as some Falmouth oysters, the green colour is associated with the presence of an excess of copper. Others, again, such as some American varieties re-embedded on our coasts, have a pale green leucocytosis, and cannot be regarded as in a healthy state.

Langworthy's investigations[2] led him to a somewhat different conclusion, for he regards 'greening' as the result of the consumption by the oyster of certain forms of green algæ, the colouring matter of which is soluble in the tissues and juices of the oyster, and apparently harmless.

After being removed from the sea, oysters are sometimes 'floated' in brackish water, with the object of 'fattening' them. It has been found, however, that the apparent increase in plumpness of the oyster under this treatment is really due to the inhibition of moisture by osmosis, and that they actually lose from one-eighth to one-fifth of their nutritive value in the process.[3]

The composition of mussels, clams, periwinkles, scallops and other molluscs is very similar to that of the oyster, and, like the latter, they cannot be regarded as foods of important nutritive value. They are also peculiarly liable to develop poisons which may produce serious, and even fatal, symptoms, and in susceptible persons their use is sometimes followed by irritation of the skin, usually taking the form of nettle-rash.

The **green turtle** is almost the only reptile used for food in this

[1] Herdman and Boyce, 'Lancashire Sea Fisheries.' Memoir I.: 'Oysters and Disease.'
[2] 'Fish as Food,' p. 17.
[3] *Ibid.*, p. 16.

country, and that chiefly in the form of soup. It is called green because its fat has a greenish colour, which, according to Sir Hans Sloane,[1] imparts a yellow tint to the sweat of those who partake largely of it. In preparing the soup, the dorsal and ventral shields are removed, scalded to remove the scales, and then boiled till the bones separate. The liquor forms the stock. The softer parts of the shield are then cut into oblong pieces, which constitute the so-called lumps of green 'fat'—really a species of gelatin. Sun-dried turtle forms a soup of equal nutritive value, and at a considerably lower cost, while the basis of mock-turtle is the gelatinous substance in the scalp of the calf. From a strictly nutritive point of view, turtle soup is certainly not worth a tenth of the price paid for it.

Frogs' legs are but rarely seen in this country, though common articles of diet on the Continent. They are derived from the large edible frog (*Rana esculenta*), and, though easily digested and of a delicate flavour, are not of high nutritive value.

The average chemical composition of the different groups of foods which we have studied in this chapter is represented in the following diagram, from which also one can derive some idea of their relative nutritive values. The diagram is constructed from the analyses published by Langworthy.

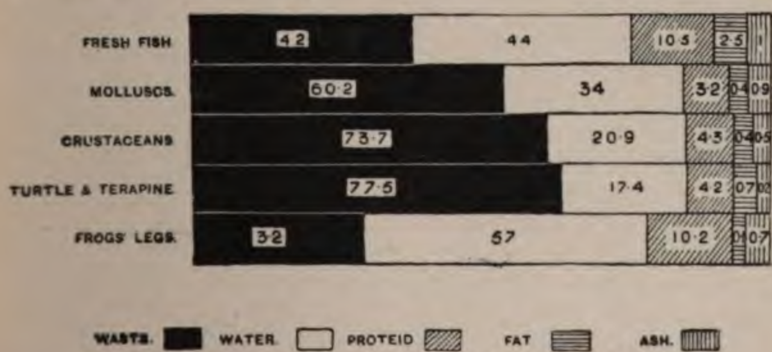

FIG. 7.—COMPARATIVE COMPOSITION OF FISH AND THEIR ALLIES.

[1] See Pereira, 'On Food and Diet,' p. 273.

CHAPTER VI

SOUPS, BEEF-EXTRACTS, BEEF-JUICES, BEEF-TEA, AND BEEF-POWDERS

WHEN meat is cut up and placed in water for the purpose of making soup, there is dissolved out of it (1) a small proportion of its soluble proteids; (2) a large part of its extractives and mineral matter; (3) a small quantity of fat. If the water is now raised to the boiling-point, the proteid is coagulated and floats to the top as a brownish 'scum,' which is usually carefully skimmed off. At the same time the proportion of extractives and mineral matter in the solution is increased, and some of the connective tissue is dissolved out in the form of gelatir.

It will be evident from these considerations that a clear soup contains chiefly the *flavouring* constituents of the meat from which it is prepared. The amount of nutritive matter in it is very small, for, as we have already seen, a solution of gelatin of even 1 per cent. strength 'sets,' and very few soups contain as much as that. This estimate of the nutritive value of a clear soup is borne out by the following example[1]: 1 pound of beef and about ⅓ pound of veal bones were boiled down in the usual way, and yielded 1 pint of strong soup. Analysis of this showed that it contained 95 per cent. of water and only 5 per cent. of solids, made up in almost equal proportions of fat, gelatin, and extractives, along with a small proportion of mineral matter. And yet this was a *strong* soup. Most clear soups contain only from 1½ to 2½ per cent. of solids. As an ordinary soup-plate holds, when full, about 7 ounces, a large helping of the above strong soup would only yield to the consumer about ⅓ ounce of solid matter, and even of that only the gelatin and fat, say about $\frac{2}{9}$ ounce, are really 'foods.'

Seeing that it is chiefly the flavouring materials of the meat which

[1] Atwater, 'Chemistry and Economy of Food,' p. 85.

are removed in making soup, it is obvious that we cannot get a good soup and a well-flavoured dish of meat from the same piece of beef. You cannot both eat your cake and have it; and although it is true that the meat, after the soup is made, has lost practically none of its nutritive qualities, yet its sapid and appetizing elements are gone.

If, then, one wants to make soup nourishing, one must simply use it as a vehicle by means of which other food materials added to it can be conveyed into the stomach. Starchy materials are often added in this way, cornflour being, perhaps, one of the commonest. Barley is similarly used in barley broth. In potato soup, too, the soup is simply a vehicle for conveying into the stomach a considerable amount of potato starch. In other cases nitrogenous matter is added, such as grated cheese or macaroni (which contains a good deal of gluten), or the soup is thickened by the addition of one of the pulses, *e.g.*, peas or lentils, the latter being amongst the most nutritious soups commonly found on the table. Animal matters may also be employed, as in the preparation of purées of chicken, fish, or game. The following analyses of two **thick soups** are taken from König:

	Water.	Nitrogenous Matter.	Fat.	Other Nitrogen-free Substances.	Cellulose.	Mineral Matter.
Pea soup ..	88·26	3·38	0·93	5·60	0·70	1·13
Potato soup	90·96	1·37	1·53	4·87	0·26	0·99

Even in these cases the nutritive value cannot be regarded as high, for half a slice of bread would contain as much solid matter as a full plateful of such a soup.

It must not be supposed, however, that clear soups are of no dietetic value. It is not an error to begin dinner with soup. It has been found that it is just those very materials (extractives and gelatin) which a clear soup contains which are most calculated to promote a flow of gastric juice, and so to further the complete digestion of the solid food subsequently introduced into the stomach. As a French writer has said, soup should be to a dinner what the overture is to an orchestra or the porch is to a house. It is a good introduction. If, then, one gets the choice of 'clear' or 'thick,' it may be well, if a solid meal is to follow, to select 'clear'; but if the soup itself is to be the *pièce de résistance*, one should certainly choose 'thick.' For this reason, when soup is served out at penny dinners or soup-kitchens, it should always be made as thick as possible, preferably by the addition of one of the pulses, such as lentils or peas. In the case of an invalid, a 'strong soup' may be a useful

means of rousing the appetite and stimulating the digestive powers of the stomach, but it cannot be regarded as a serious contribution to his nutrition in itself.

Beef-Extracts.

The valuable culinary qualities of an extract of meat were first recognised by Proust, but it was not until the matter was taken up by Baron Liebig that they became at all widely known.[1] The extract was first prepared on a commercial scale by the company authorized by Liebig in the year 1865. The factory was established in South America, as cattle can be obtained there much more cheaply than in Europe.

The method of preparation is simple. The fresh meat is simply chopped up, heated under pressure with a little water, the extract filtered and evaporated *in vacuo* and in the open. The product is the brown, sticky material with which everyone is familiar. A good sample should have a rather golden-brown colour. If too dark, it has probably been burnt, and it should have a strong and agreeable 'meaty' odour.

Liebig calculated that 34 pounds of pure beef should yield 1 pound of the extract, and that this should make 70 pints of beef-tea, every pint therefore corresponding to ½ pound of beef. He fixed the composition of the article to be sold thus:

Moisture may vary from	16 to 21 per cent.
Mineral matter may vary from	18 ,, 22 ,,
Extractives may vary from	56 ,, 60 ,,

Liebig expressly forbade the sale of any extract containing gelatin. The latter substance is so cheap, he said, that it would tempt people to add it as an adulteration, and would also prevent the extract from keeping. It would then sink to the level of 'tablets of consommé,' which he regarded as 'a kind of coloured glue.' He likewise discountenanced the addition of any salt.

It will be observed that into the composition of Liebig's extract as fixed by its inventor no proteids or albuminoids enter. A vast number of analyses, however, have been made of it in more recent times, some of which have credited it with containing these valuable nutritive constituents in considerable amount. Amongst the most striking of these is an analysis by Kemmerich,[2] which yielded the following results:

[1] See Thudichum, 'Origin, Nature, and Uses of Liebig's Extract,' London, 1869.
[2] *Zeit. für Physiolog. Chemie*, xviii. 409, 1894.

Composition of Liebig's Extract according to Kemmerich.

Water	18 per cent.
Proteids / Gelatin	30 "
Extractives	25 "
Mineral matter	20 "
Ether extract, etc.	7 "

This was certainly a very startling result, but it was not allowed to go long unchallenged, for König and Bömer[1] have submitted the above analysis to a searching criticism, and have shown, and I think conclusively, that it was arrived at by faulty methods. They point out that one could not *a priori* expect Liebig's extract to contain much gelatin, for heat is only employed in its preparation to a small extent, and, further, solutions of it do not gelatinize. They show that it contains only about 7 per cent. of albumoses, and perhaps traces of peptone, but certainly not more than 1 per cent. of gelatin, and distribute the amount of nitrogen which it contains thus:

Total nitrogen	9·28 per cent.
Nitrogen in the form of soluble albumin	Trace
Albumoses	0·96 per cent.
Peptone	Nil to a trace.
Meat bases	6·81 per cent.
Ammonia compounds	0·47 "
Other nitrogen compounds	0·83 "

One may therefore look upon the composition originally stated by Liebig as substantially correct, and regard the extract as for all practical purposes free from proteid.

It is upon the **extractives**, then, that the uses and value of Liebig's extract must chiefly depend, and for that reason we must now look a little more closely at their chemical and physiological properties.

On the chemical properties of the extractives of meat we have but scanty information. Most of them are basic substances; a few are amides. Creatin, xanthin, carnine, and the peculiar and interesting substance carnic acid, which seems closely to resemble the so-called 'anti-peptone,' are amongst the best known. These substances represent the fragments, as it were, of broken-down proteid, and are of no use as tissue-builders.

They bear very much the same relation to proteid as sand does to the sandstone out of which it has been crushed, and it is as hopeless to expect to build up tissues from them as it would be to construct a house out of sand. They are also incapable of being oxidized in the body, and so are useless as sources of heat or energy. Being

[1] *Zeit. für Analyt. Chemie*, xxxiv. 548, 1895.

neither tissue-builders nor energy-producers, they cannot be regarded as foods. Experiment confirms this, for it was found that rats which were fed on 4 grammes of meat-extract daily died quite as soon as other rats which got no food at all, and Jessop[1] quotes a writer who consumed half a pot of Liebig's extract at a sitting, and yet felt as hungry as ever afterwards.

To do Liebig justice, he recognised this himself. 'Meat-extract,' he says somewhere, 'cannot make us strong, but it makes us aware of our strength.' We have here introduced the notion that the extractives of meat act as 'stimulants,' a view which has since been frequently maintained. It must be admitted, however, that satisfactory evidence for any belief in the 'stimulating' properties of beef-extract is not forthcoming. A 'stimulant' must act either on the heart, quickening and strengthening its action, or upon the central nervous system, abolishing or lessening fatigue. Now, it has been shown that 2 ounces of Liebig's extract can be taken at one time by a healthy man without the production of any effect other than slight diarrhœa.[2] Certainly no increase in the rapidity or force of the pulse was observed.

Of course, if the extract be taken, as it usually is, dissolved in hot water, the heart's action may easily be increased, but the sipping of hot water by itself is quite capable of producing such an effect. On the other hand, the danger of any depression of the heart from the action of potash salts contained in the extract seems to have been greatly exaggerated. It has been conclusively shown that even large doses of potash salts have no effect on the pulse.[3]

As regards an influence on the nervous system the evidence is equally unsatisfactory. There is no proof that the extractives of meat act as brain stimulants in the way that tea and coffee do, but there is some evidence[4] that they are capable of removing the effects of muscular fatigue, so enabling an exhausted muscle to become active again. This may explain the beneficial effects which seem sometimes to follow the administration of beef-extract in fatigue.

It has been suggested that the action of the extractives in diminishing fatigue is comparable to the use of oil in machinery. 'Friction' is lessened and effort rendered easier. It must be remembered that this is a mere suggestion, unsupported by any definite evidence, but

[1] *Brit. Med. Journ.*, August 31, 1889.

[2] See Lehmann, *Archiv. fur Hygiene*, iii. 249, 1885; and Bunge, *Pflüger's Archiv.*, iv. 234, 1871.

[3] See Bunge and Lehmann (*loc. cit.*): 100 grammes of meat boiled for three hours yielded 2·87 grammes of extract with 0·37 gramme of potash salts.

[4] See Kobert, *Archiv. für Exper. Path. und Pharmak.*, xv. 60, 1882.

at the same time one has to face the fact that clinical observers have repeatedly affirmed the refreshing qualities of a solution of the extractives of meat. 'What more invigorating remedy, more powerfully acting panacea,' says Proust, 'than a portion of genuine extract of meat, dissolved in a glass of noble wine?'

Whilst the stimulating properties of the extractives of meat must be regarded as somewhat doubtful, there can be no question at all of their marked effect on the digestive organs. The recent experiments of Pawlow have shown that they are the most powerful exciters of gastric secretion that we possess. They are thus eminently calculated to rouse appetite and aid the digestion of any food with which they may be taken. This, indeed, is their true rôle, both in health and disease. They are flavouring agents, and their proper place is in the kitchen, not by the bedside. As Voit has rather fancifully put it, the influence of such substances as the extractives of meat on the nervous system is mainly an æsthetic one, and is comparable to the influence of a symphony by Beethoven on the ear, or of a picture by an old master on the sense of sight.

We may conclude, then, that Liebig's extract, though containing too little proteid matter to be in itself a food, may act as a valuable adjuvant to other foods, especially where appetite and digestion are feeble. The possible value of the salts which it contains will be discussed when we consider beef-tea.

What is meant, then, or ought to be meant, when one says that 1 pound of the extract is the equivalent of 34 pounds of meat, is that it contains all the *flavouring* ingredients of the latter. It does not in any sense contain the *nutritive* matter of that quantity of meat. As one might have expected, the fact that Liebig's extract is of very small nutritive value was not long in being recognised, and numerous rival preparations have sprung up which profess to contain, in addition to the flavouring ingredients of meat, some or all of its nutritive constituents. These are made by adding to the watery extract obtained from the meat a proportion of the meat fibre which in left behind. In no case, however, does the whole of the fibre of the meat seem to be returned to the extract. The reason why one believes this is clearly stated by Allen.[1] 'In the lean of meat the proteids bear to the sum of the extractives, meat bases and salts the proportion of about 4 to 1. Hence, if all the meat fibre, etc., were again added to the extract, the product would contain the solids of meat in the same relative proportions. Assuming in a preparation the presence of 70 per cent. of extractives, etc., and 10 per

[1] 'Commercial Organic Analysis,' iv. 304, footnote (2nd edit.)

cent. of meat fibre, it follows that only about 1 part out of 28 parts of fibre separated has been returned to the extract.' That the proportion of proteids to extractives and mineral matter in most of these preparations is really not much greater than 1 to 7 will be evident on an inspection of the analyses in this table:

COMPOSITION OF BEEF-EXTRACTS, ETC.[1]

	Liebig's Extract.[2]	Bovril Fluid Beef Seasoned.[3]	Bovril for Invalids.[4]	Brand's Beef-bouillon.[5]	Brand's Essence.[6]	Mason's Essence.[7]	Bouillon Fleet.[8]	Armour's Extract.[9]	Oxine Extract.[10]	Vejos.[11]	'Viking' Beef-essence.[12]
Water	18·35	38·10	21·16	36·27	87·17	77·07	61·95	15·85	62·9	25·02	90·68
Insoluble proteid	traces	8·40	8·47	3·84	—	—	—	—	—	—	—
Soluble proteid and gelatin	9·45	3·84	8·19	5·73	10·4 (5·03 = gelatin)	3·03	11·81	10·89	13·0	19·35	3·63
Extractives	29·67	12·04	16·15	19·34	1·01	7·47	9·87	43·23	4·54	21·02	1·85
Non-nitrogenous matters	18·85	19·75	29·23	19·75	—	1·58	3·81	25·91	—	17·09 (carbohydrates)	2·41
Mineral matter	23·68	17·87	16·82	15·07	1·39	9·51	12·50	2·63	19·60	14·0	1·43
Ether extract	—	—	—	—	—	1·34	0·06	—	—	1·0	

[1] This table contains analyses collected from various sources. Where more than one analysis of any preparation exists, that which seemed most reliable has been selected. The results, however, must be regarded as merely approximative, absolute accuracy in the analysis of these preparations being hard to attain owing to technical difficulties in the separation of the different constituents. This may help to explain the very discordant results often arrived at by different investigators.

For further analyses of these and similar preparations, see Allen's 'Commercial Organic Analysis,' iv.: Chittenden (*Medical News*, Philadelphia, lviii. 716, 1891), *Food and Sanitation* (1893 and 1896), and Leyden's 'Handbuch der Ernährungstherapie,' Bd. i.

[2] Tankard (Allen's 'Commercial Organic Analysis,' iv. 310). [3] *Ibid.* [4] *Ibid.* [5] *Ibid.*

[6] Analysis by Dr. Candy (unpublished). [7] Hehner (*Food and Sanitation*, April 4, 1896).

[8] Tatlock (Allen's 'Commercial Organic Analysis,' iv. 309).

[9] Hehner (*Food and Sanitation*, April 4, 1896). [10] Analysis by the author.

[11] *Lancet*, April 16, 1898 (Vejos is really a vegetable preparation made from yeast cells with the addition of other ingredients. It is included here for convenience).

[12] Tankard (*loc. cit.*).

Bovril is one of the best of the preparations which contain meat fibre. The composition of its solid matter, compared with the solid matter of lean meat, is thus given by Voit:[1]

	Bovril (Dried).	*Meat (Dried).*
Organic matter	75·3	94·6
Mineral matter	24·7	5·3
Proteids	49·7	86·7
Extractives	25·6	7·8

Voit concludes that only a small part (6 per cent.) of meat fibre has been added to the extract in this case.

Whilst the title of 'food' cannot be denied to these preparations, seeing that they do contain a certain amount of proteid, yet they are only foods in theory. Practically, they cannot be taken in sufficient quantity to enable them to be really able to contribute to nutrition.

[1] *Münch. Med. Wochensch.*, ix., 1897.

Even in the case of Bovril, a full teaspoonful only contains as much proteid as $\frac{1}{8}$ ounce of meat, and it would require about 14 ounces of such a preparation to supply an invalid with the amount of proteid he requires daily; but such a quantity he would find it impossible to consume, owing to the enormous quantity of salts and extractives which it would contain. As a matter of fact, the white of one egg will contain as much nutritive matter as three teaspoonfuls of any of the preparations in the above table. I cannot, therefore, think that these preparations are to any practical extent superior to those which contain the extractives only. It is not a question, as Voit says, of whether a preparation contains nutritive matter or not, but of *how much* it contains, and one might as well add a pinch of dried meat to a cup of tea to render it 'nutritious,' or say that air is nutritious because it contains organisms which would in an infinitesimal degree help to feed one, as hope to obtain any real nourishment by the use of such preparations as these. Not only so; the expense of these manufactured articles would alone render their use as foods impossible. One may take it that even the cheaper members of the group would only yield the 80 grammes or so of proteid which an invalid requires daily at an outlay of six or seven shillings per day.

Beef-juices.

Clearly to be distinguished from the beef-extracts is the group of preparations known as beef-juices. As their name implies, these are intended to consist of the 'juice' of meat—*i.e.*, of the fluid substance contained in the muscle fibres. They are prepared by subjecting the meat to strong pressure, and are subsequently concentrated by evaporation *in vacuo*. The use of heat must be carefully avoided in their manufacture, as it would coagulate the soluble proteids contained in the juice. This is what is meant when one reads that such and such a beef-juice 'is prepared by a cold process'; and as the plant necessary to carry out the evaporation is rather expensive, the cost of these preparations is necessarily high. Further, as one would expect, they are liable to undergo putrefaction after manufacture, and this in many of them is guarded against by the addition of some salt or glycerine or other harmless preservative. That they do in reality contain the juice of raw meat is shown by the fact that many of them at least yield the spectrum of oxy-hæmoglobin.

In order better to appreciate the relative values of these preparations, we must first look for a moment at the composition of **natural raw-beef juice** as prepared at home.

Raw-beef juice may be prepared in various ways. One is by the method of expression. If beef be squeezed very hard, juice exudes from it just as it would from an orange. Expression may be carried out at home by means of a lemon-squeezer; but this is a wasteful method, as it only succeeds in removing a part of the total amount of juice. By the use of suitable presses, wholesale manufacturers succeed in obtaining a much larger yield of juice from a given weight of beef.

Another method is the old-fashioned one of cutting the meat into small squares, and placing these in a tightly-corked bottle, which is then immersed in a saucepan of water, which is gradually heated till the water almost boils. The bottle is then left in this hot water for two or three hours. As a result of the heat the meat contracts, squeezing out as it does so a considerable quantity of rich juice. This method is also wasteful, and, unless the heat be carefully regulated, some of the proteid in the juice is apt to be coagulated.

Perhaps the best method of all is to chop up the meat, and extract the juice from it by the addition of cold water. If the mixture be left to stand for some time in a cool place, the soluble proteids and other constituents of the meat are gradually dissolved out, and are obtained on squeezing out the pulp in muslin. Of course, the juice so obtained is somewhat diluted, but to make up for this one obtains a larger quantity of it. This is certainly the most economical method of procedure.

One can see in this table the analysis of raw-beef juice

COMPOSITION OF NATURAL RAW-BEEF JUICE.

Method of Preparation.	Water.	Coagulable Proteid.	Extractives.
1. Meat from round slightly broiled and pressed[1]	88·1	6·97	3·90
2. Meat from neck slightly broiled and pressed[1]	90·1	5·18	3·56
3. Chopped beef heated in corked bottle[1] ..	92·1	2·19	2·09
4. Lean steak slightly broiled, and juice expressed with lemon-squeezer (1 lb. yielded 2½ oz.)[2]	92·9	2·90	3·40
5. 1 lb. beef and 8 oz. water stood on ice for six hours; then twisted in coarse muslin (yield = 8½ oz.)[2]	94·9	3·0	1·90
6. 4 oz. minced steak soaked for an hour in 1 oz. water, then forcibly expressed[3]	91·1	5·1	3 1

[1] Bulletin 21, United States Department of Agriculture, p. 96.
[2] Holt's 'Diseases of Children,' p. 153, 1899.
[3] Cheadle's 'Artificial Feeding of Infants' (2nd edit.) p. 115.

obtained by these different methods. It will be observed that the composition of the juice varies somewhat according to the method employed in preparing it, the amount of coagulable proteid rising in one case to nearly 7 per cent., while in another it is as low as 2 per cent. The proportion of extractives also varies a little.

In an experiment which I made myself, half a pound of good lean beef was taken and passed through a sausage-machine. Its own bulk of water was then mixed with it, and the whole allowed to stand in a cool place overnight. It was then firmly squeezed in muslin. Four and a half ounces of juice were thus obtained, containing $5\frac{1}{2}$ per cent. of coagulable proteid. This quantity was obtained at a cost of 5d. In this table there is exhibited the

COMPOSITION OF BEEF-JUICES.[1]

	Valentine's Beef-juice.[2]	Brand's Meat-juice.[3]	Lipton's Fluid Beef.[4]	Burgoyne's Meat-juice.[5]	'Esco' Beef-juice.[6]	Wyeth's Meat-juice.[7]	Armour's Beef-juice.[8]	Bovril Beef-juice.[9]	'Bovinine.'[10]	'Puro.'[11]	'Liquor Carnis.'[12]
Water	51·21	59·15	42·91	49·51	52·43	44·87	74·10	52·01	78·42	36·6	56·06
Proteids	9·65 (0·53 coagulable)	15·45 (5·28 coagulable)	22·13 (6·87 as albumin)	13·00 (3·71 coagulable)	7·6	38·01	8·3	7·23	13·32	30·33	6·96
Extractives	11·16	16·55	18·70	8·10	5·90	—	9·54	14·03	0·55	19·16	5·01
Non-nitrogenous matters	—	—	—	—	13·62	—	—	20·76 (carbohydrates)	6·01	—	28·42
Mineral matter	10·84	8·85	16·26	14·20	20·39	17·12	7·51	5·97	1·60	9·79	3·55

1 See footnote to Table of Beef Extracts.

2 Analysis by Dr. Candy (unpublished). For other analyses of Valentine's Meat-juice see Chittenden (*Medical News*, Philadelphia, lviii. 716, 1891), *Food and Sanitation* (April 22, 1893), Leyden's Handbuch der Ernährungstherapie, Forster (*Zeit. für Biologie*, xii. 475).

3 *Ibid.*

4 *Lancet* analysis (May 21, 1898).

5 Analysis by Dr. Candy (unpublished).

6 Tankard (Allen's 'Commercial Organic Analysis,' iv. 310).

7 *Lancet* analysis (supplied by makers).

8 Attfield's analysis (supplied by makers).

9 Analysis supplied by Company.

10 Hehner's analysis (Allen, *loc. cit.*, p. 309).

11 Fresenius' analysis (Leyden's 'Handbuch der Ernährungstherapie').

12 Analysis supplied by the Company.

composition of most of the beef-juices met with in the market. It will be observed that these also vary considerably in composition. Of the various ingredients, the coagulable proteid is the most important, and, as the amount of this present is not clearly stated in some of the analyses, I have estimated the quantity contained in each of these preparations, the result being embodied in the following table:

AMOUNT OF COAGULABLE PROTEID IN VARIOUS BEEF-JUICES.

	In 100 Parts by Volume.	In One Teaspoonful.
'Puro' Beef-juice	29 per cent.	1·74 grammes.
'Bovinine'	17 "	1·02 ..
Armour's Beef-juice	5 "	0·30 gramme.
Wyeth's Beef-juice	5 "	0·30 "
Bovril Meat-juice	4 "	0·24 "
Brand's Beef-juice	4 "	0·24 "
'Liquor Carnis'	3⅔ "	0·22 "
'Taurine'	1 "	0·06 "
Valentine's Meat-juice	0·3 "	0·018 "

Of these preparations, **Puro** is by far the richest in coagulable proteid. Puro is a German preparation only recently introduced into this country. In appearance it is a dark brown fluid, which when diluted with water becomes bright red, and in that condition resembles blood so closely as to lead one to expect that its appearance would prove repugnant to many patients.[1] It possesses, however, quite an agreeable flavour, and is undoubtedly extremely rich in proteid.

Bovinine, which comes next to Puro in richness in coagulable proteid, is an American product of dark brown colour, and when examined with a spectroscope shows distinctly the presence in large amount of the altered colouring matter of blood (methæmoglobin). Indeed, Professor Chittenden, who has analyzed it,[2] is of the opinion that it is prepared largely from blood. It is certainly very poor in extractives, and, in my opinion at least, possesses anything but an agreeable flavour. In spite of its cheapness, therefore, and the comparatively large amount of proteid which it contains, I cannot regard it as a preparation to be recommended.

Of the other preparations, Wyeth's, Brand's, and the Bovril Company's juices, and the preparations known as 'Taurine' and 'Liquor Carnis,' all exhibit, on examination, the appearances characteristic of the unaltered colouring matter of blood, and may rightly be regarded as uncooked juices. The amount of coagulable proteid which they contain is, however, considerably lower than that in the two preparations mentioned above.

It may be admitted that many of these preparations contain more proteid than the natural or home-made beef-juice already described. It by no means follows, however, that they are on that account of higher nutritive value. The objections urged against those beef-

[1] The colour of raw-beef juices can be disguised by serving them in a tinted glass. Their taste may be rendered more agreeable by the addition of a little wine or beef-tea.

[2] *Medical News*, Philadelphia, lviii. 716, 1891.

extracts which also pretend to be foods apply here with full force. A patient could take considerable quantities of natural raw-beef juice because it only contains salts and extractives in small amounts; but in many of the artificial preparations the ratio of these ingredients to the total proteid is so high that they could only be administered in very moderate quantity without running the risk of exciting diarrhœa and thirst. That *no* raw-beef juice, whether natural or otherwise, can really be regarded as an important aid to nutrition is evident from the fact that, even of a preparation which contains 5 per cent. of proteid, about 3 pints would be needed to supply the proteid required by an invalid daily. The administration of such a quantity is, of course, impossible. They can only be of some slight service in tiding over a crisis in which the administration of milk is, for some reason or another, impossible. As an example, one might mention cases of vomiting and diarrhœa in young children. One must be careful not to allow one's self to be misled by the examples often adduced of patients who have lived for several days 'on nothing but So-and-So's beef-juice.' Everyone knows that, provided water be freely supplied, most patients are capable of living on nothing but their own tissues for a surprisingly long period. In most of these instances there can be little doubt that the patient's own fat deserves the credit of his survival, and not the beef-juice at all.

Another objection to the use of artificial beef-juices is their expense. From the method of their manufacture, as we have seen, this is almost inevitable; but it is well to remember that, with the exception perhaps of 'Puro,' the nutriment which they contain costs many times more than it would in the form of home-made beef-juice, and in one case, at any rate, fully 200 times as much. It is really pathetic to see poor people in cases of illness paying large sums for so very small a return. In this connection, it is only right to draw attention to the very great value of egg-white as a substitute for raw-beef juice. Egg-white contains 12 per cent. of egg-albumin, and there is no reason to believe that egg-albumin is in any way inferior in nutritive value to the proteids of meat. One egg yields more than an ounce of white, and if one adds to this twice its own volume of water, and strains through muslin, one obtains 3 ounces of a clear solution containing 4 per cent. of coagulable proteid, or about as much as an average specimen of commercial beef-juice. All that remains is to stir into this a little Liebig's extract, dissolved in a teaspoonful or so of hot water, and one has 3 ounces of a solution which can hardly be distinguished from beef-juice, at a cost of little

more than a penny, or twenty-four times cheaper than most commercial juices. This preparation can be used under the same circumstances as beef-juice, and has the advantage that it can be given practically *ad libitum*.

Leube-Rosenthal's Meat Solution[1] may be mentioned at this point. It is really a partially digested preparation of meat, and is made in the following way: Beef is chopped up finely and placed in jars, with its own weight of 2 per cent. hydrochloric acid. The mixture is heated in a Papin's digester for twelve to fifteen hours, with occasional stirring, till all the fibres of the meat are loosened. It is then rubbed up in a mortar to a fine paste, and again heated under pressure for fifteen to twenty hours. It is finally neutralized with carbonate of soda, and made into a paste with water. The result is a fine 'sludge' of finely-divided meat fibre, part of which has been converted into peptone. It has the colour and taste of cooked meat, though it is perhaps rather salt in its pure form. It has the following composition:

Water	67·21 per cent.
Fat	5·93 "
Albumin	11·0 "
Peptone	6·51 "
Extractives, etc.	7·55 "
Mineral matter	1·34 "
Salt	0·46 "

One tin of it, which is recommended as a day's ration, contains ½ pound, and costs 2s.[2]

Leube claims for his solution of meat the following advantages:

1. It contains all the constituents of the original meat.
2. It is of a soft consistence, resembling an emulsion.
3. Its taste is milder than that of ordinary beef-extract.
4. It is easily digested.
5. It keeps well.

The writer has had no personal experience of the use of this substance, but it is certainly of high nutritive value; and Leube has obtained excellent results from its employment in cases of acute disease of the stomach and bowels, as well as in other conditions. It certainly deserves to be better known in this country.

We may next turn our attention to ordinary beef-tea. Now, the nutritive value of beef-tea depends entirely on how it is made. If the preparation is carried out in such a way as to insure the extraction of some at least of the proteid of the meat, then the

[1] See Leube, *Samml. Klin. Vorträge*, 1873, No. 62 (M. 22).
[2] Supplied by H. Poths and Co., Burv Court, St. Mary Axe, E C.

beef-tea will have nutritive value; on the other hand, if it is so made that only the extractives and salts of the meat are dissolved out, then it can never hope to rank as a food. Applying our knowledge of the chemistry of meat, it will readily be apprehended that the temperature at which the tea is cooked is the condition which determines whether it will turn out to be a food or not. The *wrong* way to make beef-tea is to bring it quickly to the boil, for that coagulates the proteid, and only removes the extractives and salts of the meat. Unfortunately, much of the beef-tea which is presented to sick people has been made in that way, and hence has no real value as a food; it may be 'stimulating,' or anything else one pleases, but a 'food' it never can be. If, however, one wishes to prepare a beef-tea which will contain real nutriment, one should proceed in the following way:

Get some good lean beef, and trim off with a knife any gristle or fat which is adhering to it, and then scrape the meat down thoroughly with the back of the knife so as to tear it into shreds. In this way all the fibres of the meat are removed from the connective tissue which holds them together; and it is these fibres which contain the most nourishing part of the meat. Having placed the fragments of the meat in a jar, one must now add to them some water and mix thoroughly. How much water should be added is a matter of taste. Obviously, if a small quantity of water is taken, the beef-tea will be stronger than if one used much. As a rule, 1 pint of cold water to 1 pound of beef is the proportion recommended. If the mixture is now set aside in the cold for some time, most of the soluble proteids of the meat will be dissolved out along with the extractives and salts. Some people add a little salt to the water under the belief that its solvent powers are thereby increased. It is doubtful, however, whether that is really the case. By the end of half an hour or so of standing in the cold one has got what is practically a more or less dilute raw-beef juice. The jar should now be tightly covered and placed in a saucepan of water, and the latter gradually heated up. The temperature for at least the first hour should be kept below the coagulating-point (167° Fahr.), and from time to time the mixture should be stirred with a fork, and the lumps of meat squeezed against the sides of the jar. During this time any remaining soluble proteid is dissolved out. At the end of the hour the tea must be cooked—*i.e.*, its raw appearance and taste taken away by heating it to above the point at which the red colouring matter is coagulated. The simplest plan is to bring it to the boil, and then to remove it from the fire immediately. Prolonged boiling must be avoided, as

tending to render the coagulated proteid hard and indigestible. The tea should then be poured off from the residue of beef, not strained, the lumps of beef being held back by a fork.[1] When this has been done, the residue should be squeezed very hard with the back of a spoon in a coarse strainer or sieve, and the juice which comes out added to the tea. The latter may then be set aside to cool. When cold, it will be found to have settled into two layers: a lower layer composed of flocculent particles, and an upper layer of brown fluid. The fat on the top should be removed with a heated spoon.

The reader's particular attention must now be directed to the two layers in the beef-tea. The lower, flocculent one consists of the nutritive part of the preparation—namely, the proteid. It has been coagulated, of course, by bringing the tea to the boiling-point, but the coagulation has occurred in the form of very fine light particles. Had the tea been passed through a fine strainer or through muslin, as is sometimes recommended, these particles would have been kept back, and the value of the tea proportionately lessened. The upper, or fluid, layer corresponds to what is the whole tea when the latter is imperfectly prepared; in other words, it consists of a solution of the extractives and salts of the meat.

I have found by repeated experiment that 1 pound of lean beef extracted in the above manner with a pint of water yields 28 ounces of good beef-tea, containing 1½ per cent. of proteid, and about the same quantity of extractives. The cost of 28 ounces should be about a shilling. Given these facts as to the composition of good beef-tea, what is one to say of its nutritive value? The reply is obvious. Seeing that the preparation, even when carefully made, contains only about 1½ to 1¾ per cent. of proteid, it can never be regarded as an important aid in the feeding of the sick. If one swallows a pint of it in a day, he has only consumed about one-ninth of the total amount of proteid required by a sick person. Of course, beef-tea may be given with some advantage to patients who are confined to an entirely fluid diet, provided the remaining eight-ninths of the proteid required are made up in some other form, such as milk or white of egg.

The beef-tea is a pleasant change. It seems to promote appetite to some extent, and its extractives possess, as we have seen, a refreshing influence. It may be objected to beef-tea as a food in comparison with raw-beef juice, that its proteid is present in a coagulated condition, and so is more difficult of digestion than the

[1] The nutritive value of the preparation can be immensely increased by grating down the residue of the meat into fine particles and adding these to the tea. This, however, is not always permissible.

uncoagulated proteid of raw-beef juice. I question, however, whether this objection is of any value. Coagulated proteid is only difficult of digestion when present in comparatively large masses. Now, in beef-tea the proteid forms very fine flakes, which offer a large surface to the digestive juices, and so are very easily dissolved, and I should think that they offer no appreciable opposition to solution by the gastric juice.

It is sometimes claimed for beef-tea that the salts which it contains are of value, as serving to replace those which are excreted from the body in large quantities in some diseases, notably in fevers. It must be questioned whether such a claim has any real value. The salts of the body are in a different position to the other ingredients which help to build it up. When they have served their purpose, and the tissue into whose composition they entered is entirely broken down, there is no need for the salts to be excreted. On the contrary, they can be retained in the body, and used over again to build up new tissue. The kidney forms, as it were, a kind of turnstile, through which all the soluble constituents of the body must pass on their way out, and if there is a demand for salts in the body, the kidney can refuse to allow these to escape. There is, therefore, nc need to pass in new salts by the entrance to the body when the old ones can be turned back at the exit. In other words, there is no justification for the supply of saline-containing beverages in fever.[1]

The extractives of meat are, as we have previously seen, excreted entirely by means of the kidneys. If these organs be acutely inflamed, it is of importance to diminish their work as much as possible, and for that reason beef-tea and beef-extracts should always be forbidden to patients who are suffering from acute renal disease.

There can be no doubt that mistaken ideas as to the nutritive value of beef-tea are still very prevalent, especially among the laity, and in spite of all that has been written on the subject. Fothergill, in language which is perhaps somewhat exaggerated, says on this subject: 'All the bloodshed caused by the warlike ambition of Napoleon is as nothing compared to the myriads of persons who have sunk into their graves from a misplaced confidence in the food value of beef-tea.' Jessop[2] calculates that 5·2 tons of beef are used in Metropolitan charitable institutions for making beef-tea every week, and that of this two-thirds are really wasted.

Much of this waste can be prevented by adding to the beef-tea the exhausted fibre of the meat, care being first taken to reduce it

[1] For a possible use of the salts of beef-tea in promoting osmosis, see p. 277.
[2] *Brit. Med. Journ.*, August 31, 1889.

to a state of fine division. This is what King Chambers called **whole beef-tea.** Jessop recommends that it should be prepared in hospitals as follows: 25 pounds of beef are boiled with 100 pints of water for three hours, then mashed up, and passed through a colander to reduce it to a fine powder. We thus get meat 'in suspension,' and 3 to 4 ounces of it can be given every three or four hours, making 1¾ pints in the day, which is ample.

One can also increase the nutritive value of beef-tea by adding to it baked flour or one of the patent cereal foods, or by stirring in a little somatose, nutrose, aleuronat, etc. The beef-tea then plays the part of a vehicle, and at the same time aids the digestion of the food added to it.

Mason's home-made beef-tea is suggested as a substitute for the genuine article, and has the following composition:[1]

Dried matter	10·4	per cent.
Substances precipitated by alcohol (proteids and gelatin)	7·0	"
Albumin	0·6	"
Extractives	2·1	"
Mineral matter	0·68	"

The directions recommend that a tinful (225 c.c.) should be added to a pint of water for ordinary use. This, of course, reduces its solids to about one-third of the above amounts, and leaves it with very much the same proportion of nutrients as well-made domestic beef-tea. A considerable proportion of its nitrogenous matter, however, seems to be in the form of gelatin, of which good beef-tea should not contain much.

Luff[2] has attempted to show that beef-tea prepared from such preparations as Bouillon Fleet or Kemmerich's extract contains as much nutritive matter as ordinary beef-tea, and at a smaller cost, and gives analyses to establish his case. One cannot admit, however, that his contention holds good for beef-tea prepared by the method already described, even although the fibre of the meat be not added.

BEEF-POWDERS.

Ordinary meat contains, as we have seen, 75 per cent. of water, and only 25 per cent. of solids. Any successful attempt to obtain the nutritive matter of meat in a small bulk must therefore be based upon the removal of part at least of the water which it contains.

[1] *Lancet* analysis, June 20, 1896. [2] *Lancet*, April 19, 1890.

Now, if all the water were removed, the composition of the resulting product would be about as follows:

Proteids and albuminoids	86·8 per cent.
Extractives	7·8 ,,
Mineral matter	5·4 ,,

That is to say, it would contain 86·8 per cent. of nutriment. Beef-powders have actually been prepared in this way by simply drying the meat. Of these, **Pemmican** is an example, the nutritive value of which has been further raised by the incorporation of 40 parts of fat with every 50 parts of powdered meat,[1] with the result that it is, bulk for bulk, about the most nourishing food known. A man doing hard work—*e.g.*, a Canadian hunter—can eat 2 pounds of it a day, and obtains in that way 222 grammes of proteid and 445 of fat.[2]

Mosquera Beef-meal[3] is a powder of beef which has been partially digested by the aid of the ferment contained in pineapple-juice, which has the advantage of not producing bitter by-products. An analysis of it by Chittenden shows that it contains 90 per cent. of nutritive matter, of which fat makes up 13 per cent. and proteid 77 per cent., 29 parts of the latter being in the form of albumoses and peptone. It is therefore a preparation of high nutritive value.

Somatose is a completely digested meat-powder, which will be described later (p. 512).

The objection commonly urged against meat-powders, that they are difficult of digestion, would appear to be unfounded. Dujardin Beaumetz had a large experience of their use, and strongly recommends them as not only readily digested, but also easily administered. He says that boiled beef can be easily dried on a water-bath and ground up in a coffee-mill, and makes an excellent meat-powder. It is most conveniently administered when stirred up in some fluid food, such as chocolate or milk. He finds such powders very convenient in forced feeding, as they can readily be given in a semi-fluid form through a nose-tube.

Before closing this chapter, it may be well to summarise some of the conclusions at which we have arrived:

1. The extractives of meat are incapable either of building up tissues or of supplying the body with energy, and are therefore not foods. They pass out of the body through the kidneys in the same form in which they entered it.

[1] Voit, *Zeit. f. Biologie*, xxv. 232, 1889.
[2] Charque is a similar preparation manufactured in various parts of South America
[3] Supplied by Parke, Davis and Co.

2. They do not act as cardiac stimulants.

3. They may possibly help to remove fatigue either by acting on the nervous system or on the muscles directly, but this action cannot yet be regarded as proved.

4. On the other hand, there is no doubt that they powerfully aid digestion by calling out a flow of gastric juice, whilst their pleasant flavour enables them to rouse the appetite. They are therefore useful additions to other foods, especially where the appetite and digestion are feeble, and may also be taken with advantage at the beginning of a meal, as in the form of soups.

5. If taken in large amount they excite diarrhœa.

6. Ordinary beef-extracts (*e.g.*, Liebig's) possess no properties other than those of the extractives of meat. The amount of proteid which they contain is negligible.

7. Preparations, such as Bovril, to which meat fibre has been added may theoretically be regarded as foods, but contain far too little proteid to admit of their ever being able to contribute appreciably to nutrition.

8. Beef-juices differ from beef-extracts in containing the proteids of meat in a coagulable form, the richest being the preparation known as 'Puro.' None of them, however, can be taken in sufficiently large quantity to supply much proteid to the body.

9. Natural (home-made) raw-beef juice contains about 5 per cent. of coagulable proteid, which is as much as many of the patent preparations, whilst its comparative poverty in extractives and salts enables it to be consumed in fairly large amounts. It is also very much cheaper than the patent preparations.

10. A solution of egg-white flavoured with meat-extract makes a cheap and efficient substitute for beef juices.

11. Ordinary beef-tea, even when carefully prepared, does not contain more than 2 per cent. of nutritive matters. It may aid appetite and digestion, but is of very little value as a food. Its nutritive qualities, however, can be greatly enhanced by adding to it the finely-powdered fibre of the meat ('whole beef-tea'). It is doubtful if the salts of beef-tea are of any real use.

12. Leube-Rosenthal's solution of meat is a partially digested preparation containing all the nutritive ingredients of meat in an easily digested form, and is of considerable value.

13. The only means of getting the full nutritive value of meat in small bulk is by the use of meat-powders. The alleged indigestibility of such preparations is an error. and they may frequently be turned to good account in feeding the sick.

CHAPTER VII

MILK

In the present chapter cow's milk will alone be dealt with. We shall reserve till later the study of human milk and the milk of some other animals.

1. Chemical Composition.

As regards its chemical composition, it may be remarked in the first place that milk occupies an almost unique position among animal foods, for it contains in itself representatives of all three nutritive constituents of food—proteids, carbohydrates, and fat. This peculiarity it shares, oddly enough, with oysters. This fact in itself at once raises the presumption that milk will be found to be a very valuable food.

The *proteids* of milk constitute only 2 to 3 per cent. of its total weight. The higher estimates which were current until recently are now known to have been based on erroneous analyses. The principal proteid is the substance called **casein**, which is kept in a state of more or less perfect solution by its partnership with phosphate of lime. The solution is not clear, but opalescent, and is the chief cause of the opaque whiteness of milk.

Chemists have still much to learn about casein, but enough is already known of its peculiarities to give it a unique place among proteids. To some of these peculiarities allusion will be made immediately, while the consideration of others may conveniently be deferred until we come to the study of human milk. It is only necessary to point out at present (1) that casein contains no nuclein, and seems to yield no uric acid, which fact gives milk a special place in the diet of gout; and (2) that it yields no carbohydrate when split up, which may make it of peculiar value in those severe cases of diabetes in which sugar is formed out of proteid.

The other proteid of milk is an albumin (lactalbumin), which is entirely different from casein, and especially, perhaps, in this, that it is coagulated (although slowly) when milk is boiled. It is present in very much smaller quantity than casein, making up as it does only about one-seventh of the total proteid of cow's milk. In human milk it is much more abundant.

The *carbohydrate* constituent of milk is **milk-sugar**, or lactose. Milk contains from 4 to 5 per cent. of it. It differs very much from cane-sugar, and in nothing more than its comparative freedom from sweetness. In a substance which is intended as a food rather than a condiment, this property is a valuable one. Were it not so, milk would pall upon the taste much more readily than it does. Another peculiarity of lactose is that it is hardly capable of being fermented by yeasts. As a consequence, it is better borne than other kinds of sugar in cases of advanced dilatation of the stomach accompanied by fermentation. On the other hand, it is readily split up by certain micro-organisms, with the production of lactic acid, a process which occurs in the souring of milk, and sometimes also in the intestine, producing diarrhœa. Many cases of infantile summer diarrhœa are brought about in this way.

The **fat of milk** stands intermediate in amount between the proteid and sugar, constituting about 4 per cent. of the total weight. It is interesting to note that the exact amount varies considerably with the needs of the animal for which the milk is designed. In the milk of animals which inhabit cold latitudes the percentage of fat may be very much higher than in that of the cow. Whale's milk, for example, contains 43 per cent.[1] The meaning of this adaptation is clear when one remembers the value of fat as a body fuel.

Fat exists in milk in the form of an emulsion of extraordinary perfection. It has been calculated that there are 1,500,000 separate fat globules in a drop of milk not larger than a pin's head (Rothschild). It will be evident that fat so finely divided as this must be particularly easy of digestion.

When milk is allowed to stand, the fat globules run together, and float to the surface as cream. If this be removed, **skim milk** is left; but when so prepared it still contains some fat, perhaps as much as 1 per cent. If the cream be removed by means of a centrifugal separator, its abstraction is much more complete; for separated milk usually contains less than ⅓ per cent of fat. Milk so prepared should be described as 'separated milk.'

[1] Frankland, *Chemical News*, February 7, 1890.

Some fuller chemical details about milk fat will be mentioned when we come to butter.

Mineral matter is fairly abundant in milk, forming about 0·7 per cent. Seeing that milk is the sole food of young animals, one is not surprised to learn that its different mineral ingredients are present in exactly the same proportions as in the body of the animal which the milk is designed to feed. Now, the chief tissues which a young animal has to build up are muscle and bone. For the former phosphate of potash, and for the latter phosphate of lime, is required, and both of these salts milk contains in abundance. To the rule that the mineral ingredients of milk correspond proportionately to those in the body of a young animal there is one apparent exception. **Iron** is an essential element in the body, and especially in the blood; but iron is very scantily represented in milk. Stockman[1] calculates that 5 pints of milk would be required to supply the amount of iron required by a full-grown man every day. To the young animal, however, this scarcity of iron in milk is a matter of little moment, for it enters the world with a large amount of iron already stored up in its body, which it has obtained from the blood of its mother. In the adult, on the other hand, the lack of iron means a deficiency in the supply required to keep the blood in proper condition; and for this reason persons who are kept for a long time on a purely milk diet are apt to become anæmic.

There remains one other substance which, for the sake of convenience, may be considered under the mineral ingredients of milk. I refer to **citric acid**. It is rather surprising to find this substance in milk at all, and yet it is present in no inconsiderable amount; for it has been calculated that a good cow yields as much citric acid in the day as would be contained in two or three lemons.[2]

As found in milk, citric acid is chiefly combined with lime. Calcium citrate is a gritty substance, only imperfectly soluble, and devoid of any sour taste. The solid particles sometimes met with in condensed milk consist chiefly of it. The possible significance of the presence of citric acid in milk will be pointed out when we come to the subject of infant feeding.

Last, but not least, amongst the constituents of milk is **water**. It forms by far the largest proportion of the milk (87 to 88 per cent.), and holds the other ingredients in more or less complete solution. It is owing to the large amount of water which it contains that milk in

[1] *Journ. of Physiol.*, xviii. 484, 1895.
[2] Henkel, *Münch. Med. Woch.*, No. 19, 1888, p. 328.

its ordinary state must be regarded as a dilute and bulky form of food.

One may sum up what has been stated about the chemical composition of milk in the following table:

Composition of Cow's Milk.

Water	87 to 88 per cent
Proteids	2 „ 3 „
Sugar	4 „ 5 „
Fat	3½ „ 4½ „
Mineral matters	0·7 „

These figures merely represent the average composition of a sample of good milk. They are not to be understood to apply to every specimen of milk one may encounter, for there is no food which varies more in composition than milk. Here is what two recent analytical writers have to say on this point:

'Milk,' says one,[1] 'forms in many cases the entire diet of children and invalids, and under the present conditions it varies so enormously that a doctor, in prescribing so much milk per day, does not know within 30 per cent. how much nourishment he is giving.'

'Excepting meats,' says the other,[2] 'there is probably no one article of food which is liable to so wide a variation in its percentage composition as the milk supplied to the consumer. The variations are so great, in fact, as to make it entirely possible that one man may pay nearly twice as much as his neighbour for the same amount of nutrients when both buy it at the same price per quart.'

To some extent these variations in composition are unavoidable, depending as they do on the breed and age of cow from which the milk is obtained, on the way in which the cows are fed, and on the period which has elapsed since calving.

In the mixed milk obtained from a large number of cows these variations must to a considerable extent neutralize one another. Hence it is that the total milk from one dairy varies less in composition than that from any one cow in it, and the popular prejudice in favour of feeding an infant on milk 'from one cow' is shown to rest on a false basis.

On all grounds, both commercial and dietetic, it would be well to have some standard by which to judge of the quality of the milk we buy, and by which to regulate the price we should pay for it. Seeing that it is the solids of the milk that we want, and not its water, and

[1] 'The Analysis of Food and Drugs' (Pearmain and Moor): Part I., 'Milk,' p. 12.
[2] 'Milk as Food,' Farmers' Bulletin, No. 74, United States Department of Agriculture

seeing also that the specific gravity of a fluid depends on the amount and nature of the solids dissolved in it, one might naturally suppose that in the specific gravity of a sample of milk we would have a guide to the amount of solids which it contains, and consequently to its nutritive value and the proper price to pay for it. This would be quite true were it not that fat is one of the most important solids of milk. Now, fat is lighter than water, for which reason the cream rises to the top. A specimen of milk *plus* its cream has thus an actually lower specific gravity than one from which the cream has been removed (skim milk). The artful milk-vendor has not been slow to find this out, and accordingly he skims his milk, and then lowers the specific gravity again to its original point by the addition of water. Thus he effects a double adulteration, and yet leaves the specific gravity of the milk as it was; consequently the specific gravity of milk is of no use as a guide to its composition.

In the fat of milk, however, we find a reliable gauge of its quality. Fat is not only in itself one of the most important nutritive ingredients of the milk, but a milk which is rich in cream is found to be rich in proteid, and sugar also, and a 'thin' milk which contains little cream is found to be poor in other constituents as well. Commercially, too, there is good reason for accepting the amount of fat as the standard of price, for the fat of milk is its most expensive constituent. One is convinced of that when one remembers the price of cream, and when one reflects that skim milk—that is to say, milk from which fat is the only element that has been removed—costs only half as much as the complete fluid. The last point in favour of the fat standard is the practical consideration that the amount of fat is more easily estimated than that of any other ingredient of the milk.

What proportion of fat, then, should be insisted upon? On this point, unfortunately, some difference of opinion exists. Analysis has clearly shown that an average sample of good milk contains 4 per cent. of fat. The Society of Public Analysts allows a very liberal margin for fluctuation in individual samples, and regards a specimen of milk with less than 3 per cent. of fat as adulterated. The Inland Revenue Department is even more lenient, and takes $2\frac{3}{4}$ per cent. as its standard. It is to be hoped that the time is not far off when the public authorities will insist upon a uniform standard of 4 per cent. of fat as the criterion of pure milk.

From what has been said of the chemical composition of milk, one would naturally regard it as a fluid form of food, and one knows that milk is often one of the chief elements in a so-called 'fluid' diet. Strictly speaking, however, milk is not a fluid food. It is only a

fluid outside the body. Whenever milk enters the stomach it undergoes a change by which it very soon becomes solid. It is then said to be coagulated. This **coagulation** is due to a change brought about in the casein by the ferment called 'rennin.' The exact nature of the change which the casein undergoes is still obscure, but it seems to be split up by the rennin and then to become solid; but this last stage only occurs if salts of lime are present in the solution.

The coagulation of milk is what occurs in the making of **junket**. In that process, rennet (which is simply a preparation of the ferment rennin) is added to the milk, and the latter is then set aside in a warm place until it is solid. At first the milk forms a jelly, but by-and-by the curd shrinks and a yellowish fluid is squeezed out of it, which is the 'whey.' The rennet which is used in this operation is derived from the lining membrane of the stomach of the calf, but exactly the same ferment is present in the human stomach, and it is important to remember that all the raw milk one takes is converted in the stomach into junket very shortly after it has been swallowed. We shall return in greater detail to this subject when we come to the digestion of milk.

At present it may be pointed out that the curd of milk consists primarily of the casein, and of it alone. In process of setting, however, the casein entangles the fat of the milk in its meshes, so that junket consists of the casein of the milk along with its fat.

It usually also contains some of the sugar of the milk, for the whey is never entirely squeezed out. For this reason junket may require to be avoided by diabetics.

The **'curdling' of milk** must be distinguished clearly from the process of 'clotting' just described. When milk 'curdles,' its casein is simply thrown down in the form of a precipitate without undergoing further change. When milk 'clots,' the casein undergoes profound internal alterations, rendering it practically a new substance with new characteristics.[1]

Curdling is due to the production of lactic acid in the milk, which turns the casein out of its partnership with lime salts, and the casein, being in itself not soluble, then falls down as a flocculent precipitate.

The production of the lactic acid is due to a splitting up of milk-sugar by the agency of certain organisms (*Bacterium lactis*, or *Bacillus*

[1] Many English physiologists apply the name 'caseinogen' to the chief proteid of milk, and restrict the term 'casein' to caseinogen which has been altered by coagulation. This nomenclature has the advantage of emphasizing the difference between the products of curdling and clotting above described. Adopting it, one would say that when milk is curdled caseinogen is thrown down in a flocculent form; when milk clots, the caseinogen is converted into casein

acidi lactici) always present in the milk, but the growth of which is greatly facilitated by certain external conditions, of which warmth and certain electrical conditions of the atmosphere appear to be the chief.[1] This is the reason for the readiness with which milk becomes sour in hot and thundery weather.

We have now to speak of the **effects upon the composition of milk of heating it.**

When milk is boiled in an open pan a tough 'skin' forms on the top. This consists to some extent of coagulated lactalbumin, but partly also of casein and salts of lime.[2]

The boiling of the milk, possibly by the driving off of carbonic acid gas, seems to cause some of the casein to be detached from the lime salts which hold it in solution, and it then becomes entangled with fat and floated to the surface, and is dried by evaporation into the 'skin' with which everyone is familiar. If the skin be removed, another straightway appears, and by continuing the process the milk undoubtedly loses some of its nutritive value. That the loss is never great, however, is shown by the fact that 100 c.c. of milk, if boiled for a quarter of an hour, lose at most only 0·273 gramme of proteid.[3]

Other changes observed in milk heated for a long time are that it becomes of a somewhat brownish colour, and that it has changed in taste. The change in colour seems to be due in part to a charring of the sugar in the milk, but in part also to more obscure alterations.[4] The change in taste sets in quite suddenly when a temperature of 70° C. is reached. It can be got rid of to a large extent by allowing the milk to stand for some time, after being boiled, and then straining it.

The casein seems also to undergo some alteration on boiling, for boiled milk coagulates more slowly than raw milk. To this point we shall return later.

By far the most important result of boiling milk is its **sterilization.** The significance of this cannot be exaggerated. The bacteriology of milk has been the subject of an enormous amount of research in recent years, with the results of which I cannot hope to deal at all adequately here;[5] but this, at least, one may say, that the accusation that milk is a not infrequent cause of disease has been proved up to the hilt.

[1] The influence of electrical conditions is denied by many authorities.
[2] See Harris, 'Chemistry and Coagulation of Milk,' *Journ. of Anat. and Physiol.*, 1894-95, p. 188; and Solomin, *Archiv. f. Hygiene*, Bd. 28, p. 43, 1897.
[3] Solomin, *loc. cit.*
[4] See *Maly's Jahres-Bericht*, 1895, p 210.
[5] For a useful summary of the subject, see Conn's 'Dairy Bacteriology,' Bulletin 25, United States Department of Agriculture, 1895.

Milk, as it comes from a perfectly healthy and perfectly clean cow, may be regarded as a sterile fluid; not only is it sterile, it seems even to be possessed of feeble germicidal properties. These ideal conditions, however, are difficult—one had almost said impossible—of perfect attainment. Disease in cows, especially if stall-fed, either general and constitutional (*e.g.*, tuberculosis) or local and in the udders (*e.g.*, inflammation), is of extremely frequent occurrence. It is not to be wondered at, therefore, that milk should often contain the germs of these diseases. Dr. Eastes,[1] for example, found lately in 186 samples of milk obtained from all sources that tubercle bacilli were present in 11, and the organisms of pus in 47, cases.

Far more commonly, however, the milk gets contaminated either by stagnation in the udders of the cow or from the introduction into it of foreign matter after it is withdrawn. These foreign matters are of all sorts, but are chiefly composed of manure. The frequency of their occurrence will be appreciated when one learns that it has been calculated by Dr. Backhaus that the inhabitants of Berlin consume in this way 3 hundredweight of excrementitious matters per diem.[2] The hands of the dairyman and the water used in washing the cans are other possible sources of infection.

Once arrived in the milk, the germs are able to grow and multiply very rapidly, so that in a short space of time, especially if favoured by warmth, it may be literally swarming with them.

Roughly speaking, the micro-organisms met with in milk may be divided into two classes—(1) those which produce souring, (2) pathogenic bacteria.

The former are probably harmless, unless so abundant as to produce decomposition of the milk in the intestine, when diarrhœa may be set up. Their chief significance lies in the fact that owing to their presence milk cannot be kept for any length of time without turning sour.

The pathogenic bacteria are the bearers of disease. Amongst the diseases which have been proved to be conveyed by milk are diphtheria, typhoid fever, tuberculosis (which has recently attracted an enormous amount of attention), and possibly scarlatina and cholera.

The disease germs are more easily destroyed than those which produce souring. A temperature of 75° C. maintained for a few minutes is enough to kill most of them. If the milk is to be preserved for a long time, however, this is not sufficient, and the temperature must be raised above the boiling-point (110° C.), and

[1] 'The Pathology of Milk,' *Brit. Med. Journ.*, November 11, 1899.
[2] See also Conn, *op. cit.*, p. 11.

kept there for some time. This is the process of sterilization. Sterilized milk is now prepared on the large scale by most of the leading dairy companies, and may be made at home by the aid of Soxhlet's or Cathcart's apparatus.[1]

Sterilization is undoubtedly the most efficient way of dealing with the germs in milk, but it is not without drawbacks. It alters the taste of the milk, destroys the fine emulsification of the fat, coagulates the lactalbumin, and renders the casein less easy of digestion.

Efforts have been made to overcome these disadvantages by **pasteurization.** This consists in keeping the milk at a temperature of 70° C. (158° F.) for twenty minutes or half an hour. Of this method, however, it may be said that, though it kills most of the disease germs, it has not been *proved* to destroy the tubercle bacillus, and certainly does not destroy some bacteria capable of causing diarrhœa. Further, milk so treated will not keep more than three or four days, for the acid-forming bacteria are still present; nor can one even be certain of avoiding alterations in the taste, for that change sets in, as we have seen, just above 70° C.

For ordinary purposes there is little doubt that simply boiling the milk for a few minutes is the simplest and most satisfactory method of procedure. If carried out in a double saucepan, or Aymard's boiler, very little change in taste of the milk results, especially if it be rapidly cooled after removal from the fire, and subsequently strained, as already described.

There is every reason to advocate the habitual application of one or other of these methods to milk before it is consumed as food; and one looks forward to the day when the drinking of raw milk will be considered as barbarous a custom as the eating of raw meat is at present.

2. Digestibility of Milk.

It might be supposed that milk, being a fluid, would only remain a short time in the stomach, and rapidly pass on into the intestine. But we have seen that milk is only a fluid outside the body; when it enters the stomach it sets into a solid clot, owing to the action upon it of rennin. Now, the gastric juice is an acid fluid, and it is at first sight surprising that *curdling* does not take place rather than clotting. That this does not happen is no doubt to be attributed to the fact that the alkaline salts of the milk neutralize the acid first

[1] For much practical information on the sterilization of milk, see *Year-Book of Treatment*, 1897, p. 149. Cathcart's apparatus is described in the *Brit. Med. Jour.*, January 4, 1896. It has the advantages of being cheap and easily cleaned, and can be obtained from Down, St. Thomas's Street, S.E.

secreted by the stomach, and give the rennin time to act before the mixture has attained an acid reaction at all.

Whether this be the correct explanation or not, there can be no doubt of the fact that shortly after milk has been swallowed it is converted into a solid mass.[1]

What the use of rennin is in the stomach is very difficult to see. Certainly clotting is not a necessary preliminary to the digestion of milk, for the latter process can be carried on artificially outside the body to its most advanced stages, with the milk remaining fluid all the time. There is also ample provision for the digestion of milk in the intestine, and if it be so prepared that clotting in the stomach cannot take place, its ultimate digestion is in no way interfered with, nor is it found that patients from whom the stomach has been entirely removed for disease have any difficulty in digesting milk. Rennin, in fact, would almost appear to be a superfluous ingredient in the gastric juice, and its presence here is rendered all the more inexplicable by the fact that it occurs also in such situations as the gizzards of fowls, where milk is never found at all.

After the clot of casein has formed in the stomach, it shrinks into a tough and leathery mass, which offers great resistance to the digestive efforts of the organ. Were the milk merely curdled, the case would be quite different; for the particles of precipitated casein are dissolved with comparative ease. This is one of the reasons why butter-milk and koumiss are often found to be more 'digestible' than ordinary milk.

If, then, we wish to lighten the labours of the stomach in the digestion of milk, we must endeavour so to arrange matters that the milk shall not form a tough and dense clot after it has been swallowed.

Now, it has been found that the density of the clot which milk forms in the stomach depends, on the one hand, upon the amount of casein and lime salts which it contains, and, on the other hand, upon the degree of acidity of the gastric juice. The richer the milk is in casein and soluble salts of lime, and the more acid the gastric juice, the tougher is the clot. On the other hand, by reducing the proportion of these different factors, the clotting of the milk can either be prevented altogether or made to take place in such a way that the clot is not of great toughness and density.

[1] If an artificial gastric juice containing a small quantity of rennet be allowed to drop slowly into milk at the body temperature, one invariably finds that clotting occurs before curdling. Observations on dogs by Arthus and Pagès (*Mém. de la Soc de Biologie*, 9th series, iii., 1891, p. 131), and on the human subject by Beaumont, Uffelmann and Reichmann, have shown that clotting takes place within a quarter of an hour after the milk has been swallowed.

Obviously mere dilution of the milk with water lessens the proportion of lime salts and casein, and will increase its digestibility. The dilution, however, must be in the proportion of at least half and half, if any great benefit is to be obtained from it. **Dilution with lime-water** is considerably more efficacious, one part of it to two of milk being sufficient to prevent the formation of a dense clot. One might suppose that the lime contained in the lime-water would tend to make the clot more dense; but this is not so. It is the *kind* of lime salt which is of importance, and the lime-water seems to supply that additional proportion of lime which is required to convert the salts already present into a less soluble form. One might compare its action to the softening of hard water by the process of 'Clarking.'

Barley-water is sometimes recommended as a diluent instead of ordinary water. Whilst I find that it has no greater power of *preventing* clotting than ordinary water, it seems to some extent, by its slight degree of viscidity, to prevent the clot from shrinking into a tough mass. It is certainly much inferior to lime-water as a means of improving the digestibility of milk.

'Aeration' of the milk (such as can be effected by the use of the 'Sparklets' process) is another important means of combating density of clotting. Milk so prepared clots rapidly, but the clot is very friable.[1] It is the combination of aeration and dilution that renders 'milk-and-soda' so much more digestible than plain milk.

The presence of much acid, as has been mentioned, favours the retraction of the clot into a leathery consistence. Now, the degree of acidity of the gastric juice varies in different individuals within fairly wide limits, and that may explain why some people find milk so much more easily digested than others. For this reason, too, milk may sometimes disagree in those cases of dyspepsia which are caused by over-acidity of the gastric juice.

Mere dilution of the milk will, of course, tend to reduce the acidity of the gastric contents, and so help to prevent retraction of the clot.

Alkalies act in the same direction, but more potently, by reason of their acid-neutralizing power. Some of the benefits of adding lime-water are no doubt to be attributed to its alkalinity; but ordinary alkalies, such as bicarbonate of soda, are hardly able to do much good owing to the rapidity with which they are neutralized by the gastric juice.[2]

[1] Arthus and Pagès, *loc. cit.*

[2] Reichmann found that the addition of even very large quantities of bicarbonate of soda to milk did not prevent clotting in the stomach, but interfered with the

Boiled milk is found to clot more slowly outside the body, and to give a less dense clot, than raw milk.[1] It must not be supposed, however, that it behaves similarly in the stomach. Many have fallen into this fallacy. Boiling acts in large measure by rendering some of the lime salts less soluble, but its effects are at once counteracted by the addition of a little acid, which redissolves the lime salts. Hence, in the stomach boiled milk clots just in the same manner as raw milk.

Another method of preventing the formation of a dense clot is by mixing the milk with some substance which will get in between the particles of casein, as it were, and keep them apart, so that they do not run into a solid, tough mass, but form a more or less spongy clot. Mucilaginous fluids, such as barley-water, act, as we have seen, in this fashion. Thickening the milk with a little cornflour or gruel acts similarly, so does mixture with other foods. Milk is thus more easily digested if eaten along with some solid food, *e.g.*, a biscuit, than when drunk straight off by itself.

The exact **time that milk remains in the stomach** under ordinary circumstances has been determined by causing a healthy man to drink a definite quantity of milk, and then washing out the stomach at short intervals. In this way it has been found[2] that an ordinary glass of milk has entirely left the stomach about two hours after it was swallowed, whilst a pint of milk is disposed of in about three and a half hours. By a similar method it has been found[3] that the condition of the milk has considerable influence upon the duration of its stay in the stomach. Thus:

602 c.c. (rather more than a pint) of raw milk have left the stomach after	3½ hours
„ of skimmed milk have left the stomach after	3½ „
„ of sour „ „ „	3 „
„ of boiled „ „ „	4 „

The table shows that sour milk—*e.g.*, butter-milk—is the most digestible form. The explanation of this, as has been already

formation of peptone. I find that 50 c.c. of lime-water are equal in acid-neutralizing power to 3 grains of bicarbonate of soda, yet the addition of 50 c.c. of lime-water to 100 c.c. of milk can altogether prevent clotting when 20 c.c. of artificial gastric juice are added, or only allows of the formation of a loose clot; while 3 grains of bicarbonate of soda under similar conditions have no such power. In other words, lime-water has a specific power of preventing clotting, apart from its mere alkalinity. The probable explanation of this has already been pointed out (p. 117).

[1] See Arthus and Pagès, *loc cit.*, and Cautley, 'The Feeding of Infants,' London, 1897, chap. xiii.

[2] See Penzoldt, *Deut. Archiv. f. Klin. Med.*, Bd. 53, p. 209, 1894; and Schütz, *Wiener Klin. Woch.*, No. 48, 1896.

[3] Jessen, *Zeit. f. Biologie*, Bd. 19, p. 129, 1883.

pointed out, is the fineness of the particles of the precipitated casein, which enables them to be easily dissolved. The table also confirms the popular belief that boiled milk is somewhat more difficult of digestion than raw milk.

The difference, however, is not great, nor are all observers unanimous on the matter. Verhaegen, for instance, finds[1] that 500 c.c. of boiled milk leave the stomach in two and a half hours, and a litre in three and a half hours, and Reichmann[2] even goes so far as to state that 300 c.c. of boiled milk remain one hour less in the stomach than a similar quantity of raw milk (three hours as compared with four). This result he attributes to the boiled milk forming a less dense clot. It must also be remembered that boiled milk is more concentrated than fresh milk, for if a litre of milk is boiled for fifteen minutes its volume is diminished by a quarter, and the amount of solid matter to be digested is proportionately raised.

It will be obvious from these conflicting results that the relative digestibility of boiled and unboiled milk cannot yet be regarded as finally settled. It is possible that idiosyncrasy plays a considerable part in the process.

One or two other points bearing on the digestibility of milk still remain to be mentioned. They especially affect the use of milk in diseases of the stomach.

In the first place, it must be pointed out that, thanks to its alkaline salts, and to the large proportion of proteid which it contains, milk is able to neutralize a very considerable quantity of acid.[3] In some diseases of the stomach, such as ulceration, in which it is desirable to diminish the normal acidity of the gastric juice, this property of milk makes it a valuable article of diet. It has also been pointed out by Pawlow[4] that, in proportion to the amount of nitrogen it contains, milk requires for its digestion a weaker gastric juice than any other food. Hence, the secretory work required of the stomach for its digestion is small, and this is another point in its favour in many diseased conditions of the stomach. The fat which milk contains also seems to exert a restraining influence on the amount of gastric juice secreted. It may be for this reason that skim milk is more easily digested by invalids. Lastly, milk, like soup, and a few other articles of diet, seems to produce a secretion of gastric

[1] 'Physiologie et Pathologie de la Sécrétion Gastrique,' Paris, 1898, p. 11.
[2] 'Experimentelle Untersuchungen über die Milch Verdauung im menschlichen Magen' (*Zeit. f. Klin. Med.*, ix. 565, 1885).
[3] Ten c.c. of cow's milk can neutralize 4 c.c. of decinormal sulphuric acid (Jager, *Maly's Jahres-Bericht*, 1897, p. 271).
[4] 'Die Arbeit der Verdauungsdrüsen,'' p. 189.

juice independently of reflex nervous influences. It is therefore as sure to be digested if poured into the stomach by a tube as if it had been swallowed in the ordinary way. This is by no means true of most foods.

3. Absorption of Milk.

When it has left the stomach, the milk reaches the intestine, where its digestion is completed by the juice supplied by the pancreas. This juice acts very powerfully on milk—more so than the gastric juice. By reason of this provision, there is no need to fear that milk will escape digestion, even if it be so prepared that it does not remain in the stomach, but rapidly passes through into the intestine.

The question next arises, Is the digested milk completely absorbed, or does it leave behind any considerable amount of waste residue? This question may be approached by investigating the degree to which the different constituents of milk are absorbed when isolated and given alone. Proceeding in this way, it has been found that the casein of milk is the best absorbed of proteids.

It is absorbed as well as,[1] or even rather better than,[2] the proteid of meat, whilst the fat of milk enters the blood quite as readily as the fat of beef.[3] And one may note in passing the interesting fact that the fat of aerated milk is absorbed rather better than that of milk which has not been so treated.[4] I am not aware of any experiments in which milk-sugar was given by itself, but it is usual to assume that it is completely absorbed.

Considering these facts, one would naturally expect to find that when milk was given as a whole it would be well absorbed. If the different components of it are so completely received into the blood, surely the whole of them given together will enter the blood with equal ease and completeness? But yet it is not so. Milk, when giver by itself as the exclusive diet of an adult, is not very well absorbed—worse, indeed, than any other animal food.[5] Even under favourable conditions, only about 90 per cent. of the available potential energy contained in the milk ever reaches the blood. The rest escapes from the body as unabsorbed waste. Thus, if 2 litres of milk are taken daily, the loss of dry substance amounts to 5·7 to 7·8 per cent. On 3 litres the waste rises to 10·2 to 11·16 per cent. (Rubner).

[1] Salkowski, *Berlin. Klin. Woch.*, No. 47, 1894.
[2] Marcuse, *Pflüger's Archiv.*, 1896.
[3] 'Milk as Food,' United States Department of Agriculture, 1898, p. 10.
[4] *Jahres-Bericht über Thier Chemie*, 1893, p. 46.
[5] Prausnitz, *Zeit. f. Biologie*, Bd. 25, p. 533, 1889.

Prausnitz found a loss of 9 per cent. when 3 litres were consumed daily. One gramme of dried milk ought to yield 5·733 Calories. Owing to defective absorption, it only yields in the body 5·067 Calories. The loss affects the proteids and fat about equally, and, in a notable degree, also the mineral constituents and carbohydrates.

These results apply only to the case of adults, and when milk is the sole food. When the milk forms part of a mixed diet it is much better absorbed. Thus, in an average of ten experiments given by Wait, in which milk was the exclusive food, only 92·1 per cent. of the proteid and 86·3 per cent. of the carbohydrate were digested; but in five experiments in which the diet consisted of *bread* and milk the proportion digested rose to 97·1 per cent. of the proteid and 98·7 per cent. of the carbohydrates. The large amount of water which milk contains seems to interfere with the action of the intestines when it forms the sole diet.[1]

It is an interesting and remarkable fact that milk is much better absorbed by young children than by grown-up persons.[2] Thus, even up to the age of twelve the loss of nitrogen, when milk is given alone is only 4·4 per cent., as compared with more than 11 per cent. in the adult.[3] In the case of babies absorption is even more complete, the difference being to a large extent due to a more complete absorption of the mineral constituents, the reason for which is the greater demand for lime salts in the infant. This reacts favourably on the absorption of the fat of the milk, for unabsorbed lime salts are apt to form insoluble soaps with the fat, and so hinder its absorption.

The comparative absorption of boiled and unboiled milk has been the subject of a good deal of experimental investigation. It was found that dogs[4] did not absorb the casein of boiled milk quite so well as that of raw milk, but the absorption of fat was the same in the two cases. Another observer,[5] who experimented on healthy young men, found that the nitrogen and fat of raw milk were better absorbed than the same ingredients after boiling; but this conclusion is disputed by a third.[6]

[1] 'Nutrition Investigations at the University of Tennessee,' United States Department of Agriculture, Bull. 53, p. 43.

[2] See Rubner and Heuber (*Zeit. f. Biologie*, xxxvi. 1, 1898), Uffelmann (quoted by Marcuse, *Pflüger's Archiv.*, Bd. 64, p. 223, 1896), and Camerer (*Zeit. f. Biologie*, Bd. 16, p. 493).

[3] Prausnitz, *Zeit. f. Biologie*, Bd. 25, p. 533, 1889.

[4] Raudnitz, *Zeit. f. Physiol. Chem.*, xiv. 1, 1890.

[5] Vassilieff, quoted by Cautley, 'The Feeding of Infants,' 1897, p. 214.

[6] Gaschibowsky, *Maly's Jahres-Bericht*, xxiv. 502, 1894.

It has further been found in the case of infants and calves that 'sterilized' milk which has been kept at or above the boiling-point for more than an hour is absorbed quite as well as milk which has merely been boiled in the usual way.[1] Taking the whole of the evidence, the conclusion seems to be justified, that just as boiling does not appreciably diminish the digestibility of milk in the stomach, so it does not to any important extent interfere with its absorption in the intestine. One need have no fear, therefore, that the great advantages of boiling are purchased at the cost of any noteworthy diminution of digestibility or absorption.

Two other points relating to the behaviour of milk in the intestine call for mention. The first is that milk seems to be absorbed with less expenditure of energy—that is to say, with less wear and tear upon the part of the intestine, than any other food.[2] This no doubt explains in part the great value of milk-diet in many intestinal diseases.

The other point is that milk seems to exercise a restraining influence upon putrefactive processes in the intestine. The explanation of this, whether it is to be attributed to the casein or to the influence of acids produced from the milk-sugar, is still disputed, but of the fact there appears to be no doubt. There is reason to believe that much of the value of milk diet and milk 'cures' in many cases is due to the diminished absorption of putrefactive products from the intestine which these bring about.[3]

4. Nutritive Value of Milk.

It is frequently said that milk is a perfect food. Now, this is a high claim, and can only be justified in the case of any food if it fulfils all of the following conditions:

1. It must contain all the nutritive constituents required by the body: proteids, fats, carbohydrates, mineral matter and water.

2. It must contain these in their proper relative proportions.

3. It must contain the total amount of nourishment required daily in a moderate compass.

4. The nutritive elements must be capable of easy absorption, and yet leave a certain *bulk* of unabsorbed matter to act as intestinal ballast.

[1] See Bendix, *Jahrb. f. Kinderheilk.*, xxxviii. 393, 1894; Cautley, *op. cit.*, p. 215; and Weber, *Bull. de la Soc. Med. Prat. de Paris*, 1892, p. 77.

[2] Pawlow, 'Die Arbeit der Verdauungsdrüsen,' p. 189.

[3] The alterations in the urine of patients on exclusively milk diet pointed out by Weir Mitchell ('Fat and Blood,' p. 114) are also to be explained by a diminution of intestinal putrefaction.

5. It must be obtainable at a moderate cost.

If one examines the claims of milk to be regarded as a perfect food, one finds that it only conforms to the first of the conditions above laid down.

It does indeed contain representatives of all the nutritive constituents required by the body, but it does *not* contain them in proper relative proportion. Relatively it is too rich in proteid and fat, and too poor in carbohydrate, to be a perfect food. In order to obtain the requisite 3,000 Calories of energy daily, one would require to consume about 8 pints of milk, and that would contain about 140 grammes of proteid, while 125 is all that is required. An excess of proteid and fat is necessary in the case of infants, where the body substance is being added to by growth and where a large supply of fuel is needed, but it is not necessary for adults. Milk, in fact, is a food for babes, not for men.

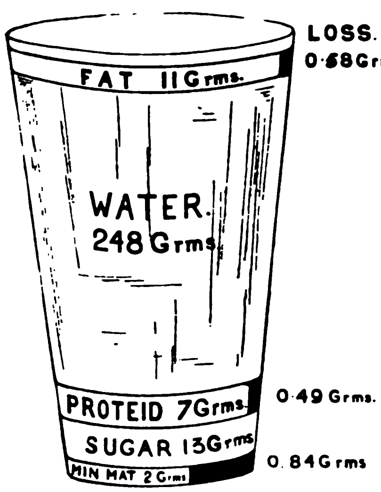

FIG. 8. — ACTUAL COMPOSITION OF A TUMBLERFUL OF ORDINARY MILK, AND PERCENTAGE OF LOSS FROM NON-ABSORPTION.

Further, milk is much too bulky to be a perfect food. For the complete nutrition of a healthy man doing a moderate amount of muscular work about 8 pints of milk would be required daily. That means that a tumblerful of milk must be swallowed every hour of the working day. This is an inconveniently large quantity, and necessitates the burdening of the system with a considerable surplus of water.

In the matter of ballast, also, milk is deficient. It is true that it is by no means completely absorbed, but the residue is not *bulky* enough to supply a sufficient stimulus to peristalsis, and milk is well known to be a constipating food.

Lastly, milk is too expensive to be a perfect food. To live on it alone would cost about 1s. 6d. a day. An ordinary mixed diet can be obtained for less than a shilling.

We conclude, then, that milk is by no means a *perfect* food. On the other hand, it is admirably adapted to be a means of supplementing the deficiencies of other articles of diet. Milk is the cheapest source

of animal proteid, and proteid is *the* ingredient which, more than any other, is apt to be deficient in a mixed diet. Eight pennyworths of whole milk yield as much proteid as ten pennyworths of beef. But milk has the advantage over beef of containing a considerable amount of carbohydrate in addition to its proteid and fat, and the result of this is that a quart of good milk is really equal in nutritive value to a pound of beef-steak. Skim milk is, as we shall see immediately, an even cheaper source from which to supplement any lack of proteid in the diet. Its great value in the dietary of persons to whom economical considerations are of importance cannot be overestimated. It is in carbohydrate that milk is specially deficient. Hence it should be chiefly used in conjunction with other foods rich in that ingredient. Such a food is bread. An interesting practical illustration of the great nutritive and economic value of a combination of skim milk and bread is furnished by the following comparison of a lunch composed solely of these ingredients with an ordinary lunch, such as might be supplied at a restaurant.[1]

Lunch of Skim Milk and Bread.				Restaurant Lunch.			
Ingredients.	Amount.	Cost.	Fuel Value in Calories.	Ingredients.	Amount.	Cost.	Fuel Value in Calories.
Bread ..	10 oz.	1½d.	755	Soup ..	8 oz.		75
Skim milk	1 pint	½d.	170	Beef ..	2 ,,		275
				Potatoes	2 ,,		100
				Turnips	1 ,,		15
				Bread ..	4 ,,		300
				Butter	½ ,,		100
				Coffee:			
				Milk	1 ,,		20
				Sugar	½ ,,		55
Totals		2d.	925	Totals		8d.	940

It will be observed that bread and milk furnished at a cost of 2d. almost as many Calories (*i.e.*, heat and energy) as were obtained from the restaurant lunch at four times that price.

The claims of skim milk to be regarded as a valuable source of food are thus amply justified, and should be carefully considered by all who are responsible for drawing up an ample and economical dietary for large numbers of persons, such, for example, as the inmates of public institutions.

Unfortunately, the prevailing tendency is to regard milk as a beverage rather than as a food. This is a great mistake, in proof of which one cannot do better than quote an extract from the valuable

[1] From 'Milk as Food.'

pamphlet on 'Milk as Food' issued by the United States Department of Agriculture,[1] and to which reference has already been frequently made. This extract states succinctly the advantages which are obtained from the liberal use of milk in a dietary:

'A very interesting experiment was recently made at the University of Maine, in co-operation with this department, in which the effect of a limited and an unlimited amount of milk was tried at the University boarding-house or "commons." From these studies the following conclusions were drawn: (1) The dietaries in which milk was more abundantly supplied were somewhat less costly than the others, and at the same time were fully as acceptable; (2) the increased consumption of milk had the effect of materially increasing the proportion of proteid in the diet; (3) the milk actually supplied the place of other food materials, and did not, as many suppose, simply furnish an additional amount of food without diminishing the quantity of other materials; (4) the results indicate that milk should not be regarded as a luxury, but as an economical article of diet which families of moderate income may freely purchase as a probable means of improving the character of the diet and of cheapening the cost of the supply of animal foods.'

As an article of diet in disease milk occupies a unique position. No single food, it may safely be said, is of so much value. The drawbacks to its exclusive use in health, which it was one's duty to point out above, are now of no account, or are even converted into advantages. The use of milk in the dietary of different diseases will be considered in detail in a subsequent chapter, but some of its general advantages may be mentioned in this place.

Being in a fluid form, milk is easily swallowed. This is a great gain in the case of exhausted patients. For the same reason, the quantity of it given can be very simply regulated and measured. Its fluid form also enables it to be used as a substitute for other beverages, and a glass of milk with each meal is one of the simplest prescriptions for increasing the amount of nourishment a patient is taking. One has frequent opportunities of recommending it to people who require to be 'fed up.'

The amount of water which it contains causes milk to be a means of quenching thirst as well as of supplying food, and makes it grateful to feverish patients. In virtue of the same property it can act as a diuretic, a function which is of great help in the treatment of

[1] Some interesting examples of menus illustrating the way in which milk may be combined with other foods to form a complete daily dietary are given in the same publication.

some forms of heart disease with œdema, in cases of renal disease, and in all inflammatory affections of the urinary passages.

The bulkiness which its richness in water entails is no serious drawback in most cases of illness. A patient who is at rest and warm in bed requires much less nourishment than an active man, and will often gain weight on 3 or 4 pints of milk a day, although more than twice that quantity is requisite for the needs of health.[1]

In addition to this, there is reason to believe that concentrated foods are not well borne in cases of severe disease, and that a moderate degree of dilution is an advantage rather than otherwise. The peculiar behaviour of milk in the stomach and intestine, the fact that it is digested with little secretory effort and absorbed with but a moderate expenditure of energy, and that its presence tends to restrain the development of intestinal putrefaction, have been already referred to, and mark milk out as a food of special value in gastro-intestinal disorders. To these advantages should be added the facts already mentioned, that, though rich in proteid, milk is devoid of such 'stimulating' substances as are found in meat, and that its use is attended by a diminution in the excretion of uric acid.

It is probably to a combination of these advantages that 'milk diet' and 'milk cures' owe the benefits obtained from their use.

From an early age milk was regarded as a sovereign remedy in many diseases By Hippocrates, Celsus, and Galen it was recommended in phthisis, and especially in gout. Amongst medieval writers Van Swieten and Hoffmann also recognised its great virtues, whilst its most strenuous advocate in modern times has been Dr. Karell, late physician to the Czar of Russia.[2] Donkin also did much to make its virtues known, while in later years it has attained prominence as an important part of the 'Weir-Mitchell treatment.'

Karell recommends a trial of the milk cure in dropsies, asthma, neuralgias of intestinal origin, cases of 'malnutrition,' and some diseases of the liver. Its use in diabetes, obesity, and some forms of valvular heart disease will be considered later.

The directions given by those who have had most experience of its use are that the milk should be skimmed, and should be given quite fresh, not boiled. 'A temperature of 212° F., I feel assured,' says Donkin, 'either seriously impairs or altogether destroys its therapeutic energy, possibly by altering the molecular constitution

[1] See Horton Smith, *Journ. of Physiol.*, xii. 42, 1891, and Prausnitz, *Zeit. f. Biologie*, xxv. 533, 1889; also Weir Mitchell, 'Fat and Blood,' chap. viii.

[2] 'On the Milk Cure,' *Edin. Med. Journ.*, xii. 97, 1866. An interesting historical résumé of the therapeutic uses of milk will be found in Donkin's 'Diabetes and Bright's Disease,' 1871, chap. i.

of the casein or by destroying some vital property with which it is endowed.'

At first not more than 2 to 6 ounces should be given, at regular intervals of three or four hours, none being given at 4 a.m. The milk should be *sipped*, not swallowed at a draught, and may be given either warm or cold as preferred. By the third day the quantity at each feed may be increased to half a pint, so that in all 3 pints are consumed. By the end of a week the total may have risen to 6 pints per day, but one should not attempt to go much above this. The 'cure' should last five or six weeks.

Amongst the 'normal' symptoms exhibited by a patient on a purely milk diet are a certain amount of drowsiness and the passage of a large quantity of urine of a pale greenish colour, which gives no brownish-red ring on the addition of nitric acid. The tongue is covered with a white fur, and there is often a sweetish taste in the mouth. A moderate degree of constipation is a good sign, orange-coloured stools being passed at intervals of two or three days. If this symptom becomes too pronounced, a little coffee or caramel may be added to the morning's milk, or a little stewed fruit may be taken once a day. Diarrhœa is due to the use of a too rich milk.

The objections, frequently of a fanciful nature, which are often urged by the patient at the beginning of such a regimen must be overcome by firmness and tact, while in some cases the addition of a little tea, coffee, caramel, or salt may make the milk more endurable.

CHAPTER VIII

FOODS DERIVED FROM MILK

Whey—Cream—Butter—Butter-milk—Koumiss and Kephir—Casein preparations.

WHEY.

WE have already learnt that **whey** is the fluid which exudes from clotted milk. It is best prepared by adding to 30 ounces of milk heated to 104° F. two teaspoonfuls of rennet, and setting aside in a warm place for a few moments till clotting has occurred. The clot must then be broken up very thoroughly by stirring, and the whole strained through muslin. About 22 ounces of whey should be obtained with (approximately) the following **composition**:

Water	93·64 per cent.
Proteid	0·82 ,,
Fat	0·24 ,,
Sugar	4·65 ,,
Mineral matter	0·65 ,,

Whey can also be made by precipitating the casein by means of an acid—*e.g.*, a sour wine. It is in this fashion that white wine whey is prepared. Alum whey is a similar product.

Whey, as its composition indicates, is a fluid of but small nutritive value. It hardly ever enters into an ordinary diet, but is often an aid in the feeding of infants.[1] It has slight laxative properties, and should be avoided when there is any tendency to diarrhœa.

The so-called **whey cure** is a means of treatment sometimes resorted to in cases of dyspepsia, especially when occurring in gross feeders ('abdominal plethora'). Its range of usefulness is much the same as that of the grape cure, and, as in it, large allowance must be made for the favourable influence of the open air and exercise which form a part of the regimen. The quantity of whey consumed is at

[1] See Ashby, *Edin. Med. Journ.*, April, 1899, p. 389.

first limited to a tumblerful night and morning, but the amount is gradually increased until a maximum is reached of ten tumblerfuls per day. The only other foods allowed are vegetables and fruits.

It should be added that whey is sometimes a useful addition to the diet in cases of nephritis accompanied by constipation.

CREAM.

Cream consists essentially of the fat of milk. It would be a mistake, however, to suppose that it consists of that alone. It contains in addition proteid and sugar in fully as high proportion as milk itself. The real difference, indeed, between milk and cream is that in the latter some of the water of the milk has been replaced by fat.

The exact amount of fat in cream varies very much, the differences depending to a large extent on the method by which the cream has been separated. In cream produced by a centrifuge the proportion of fat may amount to 65 per cent., while in ordinary cream, obtained by skimming, it may be merely 20 per cent. or less. The average amount of fat in specimens of cream examined by Droop Richmond in 1894 was 48·9 per cent. In 716 samples obtained from the London market in 1889 Vieth found an average of 45½ per cent. for single and 53½ for double cream.[1]

On an average, perhaps, one may say that a sample of good cream should contain 41 per cent. of fat. There is thus as much, or even greater, need for fixing a legal standard for cream as there is for milk. Some authorities[2] would fix the standard at 45 per cent. of fat; others would make it illegal to sell as cream anything which contains less than 25 per cent.[3]

The well-known Devonshire or clotted cream is a special variety prepared by heating the milk in deep pans, which causes a rapid and very complete separation of the fat. The proportion of fat in such cream is not far short of 60 per cent., as is shown in the following analyses:[4]

	Water.	*Proteid and Sugar.*	*Fat.*	*Ash.*
1.	32·48	8·60	58·21	0·71
2.	35·54	6·80	57·09	0·57

Devonshire cream contains only about half as much sugar as ordinary cream. For this reason it is peculiarly suited to be a source of fat in the dietary of diabetics.

[1] *Milchzeitung*, 1889, p. 142.
[2] Pearmain and Moor.
[3] Wynter Blyth.
[4] Droop Richmond, *Analyst*, 1896, p. 88.

In a physiological sense cream is chiefly to be regarded as a fuel food. It has been calculated that a pint of it should yield about 1,425 Calories, or about as much as 1⅛ pounds of bread or 1½ dozen bananas or 4½ pounds of potatoes.

In sick-room feeding it is an important aid in getting fat into the diet, for it is a very easily digested form of fat. Good cream (45 per cent.) contains as much fat as a similar quantity of most cod-liver oil emulsions, and is usually much better borne. A gill of it per day is a not uncommon prescription.

Cream, however, is by no means an economical source of fat. One and a half pints of it do not contain any more fat than a pound of butter, but the former would cost about three times as much as the latter. Cream, therefore, is to be regarded as a luxury.

Butter.

Butter is produced from cream by churning. This causes all the little fat globules in the cream to run together into a solid mass, while the fluid part, containing almost all the sugar and most of the casein, is removed in the form of butter-milk. The flavour and aroma of butter are due to the growth of organisms in the cream during ripening; butter prepared from pasteurized cream is devoid of flavour.[1]

The trace of casein which remains in the butter is of importance, for the decomposition which it undergoes on keeping is apt to make the butter turn rancid. The presence of water in the butter facilitates this change. Butter can be made to keep indefinitely by melting it down, and then boiling till all the water is driven off, as evidenced by the cessation of violent ebullition. The melted butter is then strained through muslin to remove the casein, poured into a bottle, and allowed to cool. If corked up, it will keep almost indefinitely, and when wanted a portion can be removed with a cheese scoop, or the butter can be melted and poured out by standing the bottle in hot water for a short time. This method is largely used in India for the preservation of butter (ghee), and also on the Continent.

The exact amount of fat in butter varies within fairly wide limits, but averages about 82 per cent., or twice as much as the amount in cream. An ounce of butter, therefore, may be reckoned as the equivalent of ⅘ ounce of pure fat. In addition butter contains 12 to 15 per cent. of water and about 2 per cent. of non-fatty organic matter, chiefly casein and milk-sugar.

[1] See Ninth Annual Report of Storrs Agricultural Experiment Station, 1896.

The most striking chemical characteristic of butter fat is its richness in those fatty acids (butyric, caproic, capric, and caprylic) which are soluble in water. Of these it contains about 7 per cent. Butyric acid, indeed, may be said to be the hall-mark of butter, from which it derives its name. Of the insoluble fatty acids present oleic is the most abundant. Butter fat contains 40 per cent of olein. This means that it has a low melting-point (31-34° C.), and that in its turn implies, for reasons we have already discussed, that it is easily digested and absorbed. As a matter of fact, butter is the most easily digested of fatty foods. The fat of the human body has also a large proportion of olein, and melts at an even lower temperature than butter (25° C.). The fact that butter fat approximates so closely to it in its proportion of olein may perhaps help to explain the great value of butter as a food.

The ease with which butter is digested renders it of great value as a source of fat in the diet of sickness. In phthisis, diabetes, and many forms of dyspepsia, patients can take ¼ pound of it a day without difficulty, and with great advantage to their nutrition. Cooked butter, on the other hand, is much more apt to disagree, probably owing to the liberation of fatty acids in it by the heat employed in cooking. The absorption of butter in the intestine is very complete. Even when ¼ pound of it is taken per day, less than ·5 per cent. is wasted. This is a more favourable result than would be obtained with any other form of fat, and should teach us that it may be well to give butter a fair trial before having recourse to cod-liver oil or other medicinal fatty preparations.

MARGARINE.

From what has been said as to the chemical composition of butter, it will be apparent that if one could remove from ordinary animal fats their more solid constituents (stearin and palmitin), leaving only olein, one would get a substance which would resemble butter very closely. As a matter of fact, that can be done, and the product is the substance known as **margarine**.[1]

Margarine owes its origin to the ingenuity of the French chemist Mèges-Mouriès, and was first manufactured under his direction for use in the French Navy in the year 1870. It is made by melting down and clarifying various animal fats, that of the ox being now

[1] Margarine derives its name from 'margarin,' a supposed fat, really a mixture of palmitin and stearin. It is also known as 'oleomargarine,' 'butterine,' and 'Dutch butter,' but by the Act of 1887 all butter substitutes are now described as 'margarine.' In the United States the term 'oleomargarine' is employed.

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chiefly employed. The melted fat is allowed to cool slowly, with the result that the stearin solidifies first. The more fluid components (palmitin and olein) are removed by pressure and churned up with a little milk to give them the flavour of butter. The product is then tinted with some vegetable dye, and is ready for use. It has the following **composition** :[1]

Water	9·3	per cent.
Protein	1·3	„
Fat	82·7	„
Ash	6·7	„

It will be observed that the proportion of fat is exactly the same as in an average specimen of butter, and the only point in which the two differ is that butter has a much higher proportion of the soluble and volatile fatty acids.[2] There is no reason to believe that this is in any way to the disadvantage of margarine as a food. The fat of our bodies contains no soluble fatty acids, and human milk fat is almost destitute of them too. Indeed, one might almost regard the absence of butyrin as a point in favour of margarine, for when butter becomes at all rancid butyric acid is liberated from the butyrin, and butyric acid is an exceedingly irritating substance. The comparative absence of casein in margarine is also a good point, for casein, as we have seen, tends to promote the decomposition of butter, and its absence should help margarine to keep better.

So much from the chemical side. From a physiological point of view margarine is equally deserving of recommendation. It is absorbed almost as completely as butter, the difference being only about 2 per cent. In other words, 102 pounds of margarine are equal in nutritive value to 100 pounds of butter.[3] Whatever may once have been the case, margarine is now made only from pure animal fats, and the processes to which it is subjected in manufacture insure its further purification. As its flavour is equal to that of an average specimen of butter, and as it has the advantage of being very much cheaper, there is every reason to wish that the prejudice against it, which is still rather widespread, should quickly disappear, and that it should be welcomed as an admirable and cheap substitute for a rather expensive, but necessary, food.

Before leaving the subject of butter, one may consider for a moment what is its relative value as an addition to the diet when **compared with jam.** This subject is one of very considerable interest

[1] Average of thirty-five analyses by Atwater.
[2] Butter has 7½ per cent. of butyrin ; margarine has only 0·25 per cent.
[3] See Röttger, 'Lehrbuch der Nahrungsmittel Chemie,' p. 182.

to the poorer sections of the community, and involves really two questions: (1) To what extent can sugar (which is the most important ingredient of jam) replace fat in the diet? and, (2) Is the replacement effected at a saving of expense?

The first of these questions has been dealt with to some extent in a previous chapter (p. 25). It need only be repeated here that 1 part of fat is equal to 2¼ parts of sugar in fuel value, and that sugar and fat can replace one another to a considerable extent provided these proportions be observed. It would seem, however, although one cannot give any definite scientific reason *why* it should be so, that fat cannot be wholly replaced in the diet by sugar or other carbohydrate without detriment to health, and that this is especially true of young children.

As regards the second question, it can easily be shown that, even were the substitution of jam for butter justifiable on physiological grounds, it cannot be effected with any real economy. It would require about 3 pounds of jam to be equal in fuel value to 1 pound of butter, and at current prices the former would cost about 1s. 3d., the latter, say, 1s. 2d., a difference slightly in favour of butter.[1] In order, therefore, to effect any saving by substituting jam for butter, one would require to eat less of the former than would really replace the butter, the result of which would be that one's nutrition would suffer. The money saved would be balanced by vigour lost.

The subject is further complicated by the fact that it takes a greater weight of jam than of butter to cover any given piece of bread. I have found that an ordinary slice of bread, when spread the usual thickness, is covered by 40 grammes of jam or by 8 grammes of butter. In other words, as actually used, it takes 5 pounds of jam to go as far as 1 pound of butter; and although it is true that the number of Calories yielded by the former quantity is about one-third greater than that obtained from the latter, yet the cost is also considerably greater.

Notwithstanding, then, that the cost of butter and jam is, from a nutritive point of view, almost equal, the housewife will always find the latter more costly than the former, simply because more of it is used. It is true that the extra quantity of jam conveys some extra

[1] This calculation is based on the assumption (1) that 1 part of fat is equal in fuel value to 2¼ parts of carbohydrate, and (2) that ordinary jam contains about 60 per cent. of sugar (see a paper by Aitchison Robertson, *Scottish Medical and Surgical Journ.*, July, 1898), and a good sample of butter 82 per cent. of fat. Some physiologists (*e.g.*, C. Voit) assume a different ratio between fat and carbohydrate, namely, that 100 parts of the former are equivalent to 175 of the latter. On this basis, 2½ pounds of jam would be equal in value to 1 pound of butter, and the former would cost 1½d. less than the latter.

carbohydrate into the body, but that result could be achieved at less cost by the consumption of a larger amount of bread.

At the same time, it must be admitted that one pays dearly for the pleasant flavour of butter. As far as nourishment is concerned, a pound of dripping is more than the equal of a pound of butter, and only costs half as much.

We have here another example of the fact, already so often pointed out, that in buying foods we pay usually for the likings of the palate rather than for the needs of the body. For those who can afford it, that may be quite justifiable, but for the poor the advantages of margarine and dripping as cheap ources of fat cannot be too strongly insisted upon.

Butter-milk.

Butter-milk is the fluid which is left after the fat has been removed from cream by churning. Its sourness is due to the presence of lactic acid, of which, however, it does not usually contain more than ½ to ⅓ per cent. Its general **composition** is shown in the two following analyses:

	Proteid.	*Fat.*	*Carbohydrate.*
1.	3·0	0·5	4·8[1]
2.	2·37	0·4	3·79[2]

The chief point in which it differs from milk is its poverty in fat. In this respect it resembles skim milk. The loss of milk-sugar from the formation of lactic acid is too small to be of any significance.

It is very easily digested, owing to the absence of fat and to the fact that its casein is present in a finely flocculent form.

Its nutritive value is considerable, an ordinary glass yielding about as much nourishment as 2 ounces of bread. It is as a cheap source of proteid, however, that butter-milk is chiefly deserving of notice. In respect of this constituent, it is not one whit inferior to ordinary milk, and yet butter-milk is usually thrown out to the pigs. There can be no question that there is here a great waste of a very valuable food. When used in large quantities, butter-milk has diuretic properties which may be a slight disadvantage in health, but would rather enhance its value than otherwise in many cases of disease.

Koumiss and Kephir.

Koumiss is a milk preparation of very considerable antiquity. We find authentic accounts of it in books written early in the thirteenth

[1] Atwater. [2] Dunlop, 'Report on Prison Dietaries,' p. 21, 1899.

century, and hints of its existence almost as far back as the dawn of Christianity itself.

Koumiss is fermented mare's milk. Kephir is a more modern substitute for it produced from the milk of the cow.

The home of koumiss is in the steppes of European Russia and of Central and South-Western Asia. Its brewers are tribes of nomadic Tartars; its source the milk of the hardy mares of the steppes.

Kephir is, as it were, a spurious koumiss, and was first produced in the Caucasus Mountains from cow's milk fermented with kephir grains.[1]

It may be regarded as bearing much the same relation to koumiss that margarine does to butter. It probably has, for all practical purposes, the same nutritive qualities and value as koumiss, but it is not the genuine article, and most likely it would never be used as a substitute were it not for the difficulty of obtaining mare's milk in civilized countries. The fermentation which milk undergoes in the process of conversion into koumiss or kephir is a double one. The sugar of the milk is partly converted into lactic acid by the same process which takes place when milk turns sour; in part also it undergoes the same changes as those by which wine is produced from the sugar contained in the juice of the grape. A 'lactic' and a 'vinous' fermentation both go on. The former begins first, but the latter lasts longest, and the chief anxiety of the koumiss-maker is to promote the growth of the vinous ferment and to restrain that which produces lactic acid.

Now, it is found that mare's milk is a better medium for this double fermentation than is the milk of the cow, and it is so, oddly enough, for those very reasons which make it a poorer food than cow's milk. Mare's milk contains less casein and fat than cow's milk, but is richer than the latter in sugar. Not only so: the sugar of mare's milk seems to lend itself more readily to lactic acid fermentation than the sugar of cow's milk does. The richness of cow's milk in fat is a positive disadvantage in the process of fermentation, for there is apt to be produced from it small quantities of butyric acid, which is extremely irritating to the stomach, and renders the 'brew' unfit for consumption. So much is this the case, that even if the

[1] Kephir grains resemble little fragments of cauliflower. Their fermentative power appears to be entirely due to the *Saccharomyces mycoderma*. In addition to this, they contain lactic-acid-producing organisms. The so-called *Bacterium dispora Caucasica*, which they also contain, does not appear to play any essential rôle in the process, unless, perhaps, it helps to liquefy the precipitated caseinogen (see *Nature*, xxx. 216; also Rothschild, 'L'Allaitement,' Paris, 1898).

mares are allowed to pasture on rich grass for but one day the milk of that day becomes unduly rich in fat, and cannot be safely used for the production of koumiss.[1] Hence it is that, if cow's milk is to be fermented—*i.e.*, if one wishes to make kephir—it must first be made to approximate in composition to mare's milk by being skimmed or diluted, or even submitted to both processes.

The chemical changes which take place in the milk under the double fermentation are not difficult to follow. The lactic ferment simply changes part of the sugar into lactic acid. The vinous ferment eats up a very small part of the proteid of the milk, and at the same time produces from the sugar a little alcohol and a good deal of carbonic acid gas. The milk thus becomes sour, it effervesces, and is weakly alcoholic. But the lactic acid causes the casein to be precipitated just as it does in the ordinary souring of milk, and the casein falls down in flocculi.

Now, one of the essential points in the making of koumiss is that during the whole process of fermentation the milk should be kept constantly agitated by stirring. This agitation is primarily intended to permit of the access of oxygen to the fermenting fluid, but it has also the result of breaking up the precipitated casein into exceedingly fine particles, and it is to this extremely fine state of division in which the casein is found that much of the ease with which koumiss can be digested is to be attributed. As the process goes on, it would appear[2] that a small part, at least, of the casein undergoes a sort of spontaneous digestion, and is converted into soluble products.[3] One certainly finds that ordinary kephir contains a small amount of peptone.

These changes, of course, only go on gradually, so that at the end of twelve hours of fermentation one gets a 'weak' koumiss which is only slightly sour, and which still looks and tastes quite milky. After twenty-four hours have elapsed some of the casein has been redissolved, with the result that the koumiss is thinner; it has also increased in sourness. This is called 'medium' koumiss. After another twenty-four hours or more most of the sugar has been destroyed, and the 'strong' koumiss which results is a thin, sour fluid which effervesces briskly. In this form it can be kept indefinitely without undergoing much further change.

The net change which has taken place in the original milk may be summed up by saying that the sugar has been to a large extent

[1] Carrick, 'Koumiss,' pp. 45, 54.
[2] *Ibid.*, p. 41; also *Food and Sanitation*, May 22, 1897.
[3] Acid albumin, albumose and peptone (*vide Food and Sanitation*, May 27, 1897).

replaced by lactic acid, alcohol, and carbonic acid gas; the casein has been partly precipitated in a state of very fine division, and partly predigested and dissolved, while the fat and salts have been left much as they were.

That this is an accurate summary of what takes place is borne out by the following analyses:

	Proteid per cent.	Sugar per cent.	Fat per cent.	Salts per cent.	Alcohol per cent.	Lactic Acid per cent.
Koumiss[1]	2·2	1·5	2·1	0·9	1·7	0·9
Kephir[2]	3·1	1·6	2·0	0·8	2·1	0·8
Mare's milk[3]	2·6	5·5	2·5	0·5		
Cow's milk[4]	3·3	4·8	3·6	0·7		
Butter-milk[5]	3·8	3·3	1·2	0·6	—	0·3

It will be observed from the table that the total proteid is hardly less in koumiss and kephir than in mare's and cow's milk respectively. In koumiss the fat is practically the same as that in mare's milk, while the percentage of fat in kephir is naturally lower than that in cow's milk owing to its partial removal before fermentation is begun. The sugar in both milks is very considerably reduced, and is partly replaced by nearly 1 per cent., or sometimes even 1½ per cent., of lactic acid.

The amount of alcohol in both koumiss and kephir is less than 2 per cent. This is not more than the percentage present in many so-called temperance beverages, and is below the standard fixed by the Excise. As a matter of fact, it is impossible to get drunk upon koumiss, no matter how much of it is consumed.[6] At most only a slight degree of 'hilarity' is produced, followed by sleepiness, but no headache.

Looking at koumiss in the light of what we have already learnt as to the digestibility of cow's milk, one will easily perceive that the process of fermentation must render the latter much more easily digested and absorbed than it is in its natural state. The casein—the great obstacle to the easy digestion of cow's milk—is in such a form that it cannot form masses in the stomach, but is readily attacked by the digestive juices; indeed, it is already partly digested. The carbonic acid stimulates the stomach to a more abundant secretion of gastric juice and promotes the absorption of the fat (see

[1] Rubner, 'Leyden's Handbuch,' p. 93. [2] *Ibid.*
[3] Wynter Blyth, 'Foods,' 4th edit., p. 258.
[4] Pearmain and Moor, 'Milk and Milk Products,' p. 4.
[5] Rubner, 'Leyden's Handbuch,' p. 94.
[6] Dahl, quoted by Carrick, *loc. cit.*, p. 113.

p. 120). The alcohol present co-operates in aiding the process of digestion by causing the blood to flow more briskly through the stomach and intestine, and in addition serves as a food itself. The lactic acid reinforces the digestive action of the acid of the stomach, and may, perhaps, in itself contribute heat and energy to the body.

In the matter of **absorption** koumiss and kephir also compare favourably with ordinary milk. May[1] administered to a patient 6,432 grammes of kephir in two days, containing 724 grammes of solid matter. He found that the percentages of loss in the stools were as follows:

Dry substance	6·4 per cent
Nitrogen	0·4 ,,
Fat	3·9 ,,
Ash	34·9 ,,

The absorption here was evidently better than that of milk, especially as far as nitrogen and fat are concerned.

In the light of these facts one has no difficulty in understanding how it is that enormous quantities of koumiss or kephir can be disposed of in the body without any difficulty. We read, for instance, that the healthy dweller on the steppes is capable of consuming 3 or 4 gallons of koumiss on a hot summer's day, while even the debilitated stomach of the consumptive is equal to disposing of ten large champagne bottlefuls in the twenty-four hours.[2]

To the enormous quantity of nutriment thus obtained, rather than to any mysterious properties, the undoubtedly high curative value of koumiss in consumption and other wasting diseases is to be attributed. Postnikoff sums up its nutritive qualities in the three words, 'nutrit, roborat, alterat.'[3]

It has been calculated that 4 litres ($3\frac{1}{2}$ quarts) of an average brand of koumiss will contain the following amount of nutritive material:

Proteid	140 grammes =	600 Calories
Fat	80 ,, =	744 ,,
Carbohydrate	140 ,, =	574 ,,
		1,918 ,,

This is two-thirds of the total amount of Calories required by a man doing moderate work, and contains more than the entire amount of proteid he needs daily, and yet $3\frac{1}{2}$ quarts of koumiss can be taken without any difficulty.[4]

[1] *Maly's Jahres-Bericht*, xxv. 454, 1895.

[2] Carrick, *loc. cit.* See also Dr. Stange on Koumiss Cures (Ziemssen's 'Handbook of General Therapeutics,' appendix to volume on 'Dietary of the Sick').

[3] *Food and Sanitation*, May 27, 1897.

[4] In the very dry atmosphere of the steppes these enormous quantities of koumiss can be taken, but in the damper climate of England only a more moderate amount can be compassed.

A glance at the table shows also that kephir is almost identical in composition with genuine koumiss ; indeed, being prepared from cow's milk, it is richer in casein, and must therefore be regarded as rather the better preparation of the two, unless for those of very feeble digestive powers. Good kephir is now prepared by most of the large dairy companies, but it is still rather expensive, a large champagne bottleful costing about a shilling. In physiological properties it seems to be identical with the article prepared from mare's milk. The koumiss cure is thus brought to one's own door, and no longer necessitates a journey to the steppes.

Casein Preparations.

In practical dietetics, the want of a tasteless, compact, easily digested and moderately cheap preparation of pure proteid is often felt. Casein is admirably adapted to meet these requirements. One is not surprised, therefore, to learn that casein has been separated from milk and introduced as a dietetic preparation on its own account.

Pure Casein is prepared on a large scale by the Protene Company,[1] and forms the basis of the various patented preparations which they produce. It forms a white powder not unlike flour in its general appearance, and is termed **Protene Flour**.

Sanose[2] is a powder consisting of 80 per cent. of pure casein and 20 per cent. of albumose derived from white of egg. The addition of the albumose enables the casein, when mixed with water, to remain in a state of suspension,[3] the mixture having an opaque white colour exactly like that of milk. On standing for some time, however, some of the casein is apt to fall down as a fine powder. It is this insolubility of casein which is the great obstacle to its use in its natural condition, preventing it from being conveniently added to ordinary fluid foods.

This difficulty has been overcome by causing the casein to unite with an alkali, the resulting compound being very easily soluble. A sodium casein compound of this sort is sold under the name of **Nutrose**[4]; a similar preparation into which ammonia enters is called **Eucasin**.[5] Both of these dissolve easily, forming tasteless and colourless solutions admirably adapted for mixing with other foods. Ten gallons of milk yield about 2 pounds of these preparations.

[1] 36, Welbeck Street, W.
[2] Zimmermann, 9 and 10, St. Mary-at-Hill, E.C.
[3] See Schreiber and Waldvogel, *Deut. Med. Woch.*, Therap. Beilage No. 9, October 7, 1897, and the *Therapist*, January 15, 1898.
[4] Farbwerke vom Meister Lucius und Brünig, 46, St. Mary Axe, E.C.
[5] Anglo-Continental Chemical Works, Limited, 1 and 2, Rangoon Street, E.C.

The most recent preparation of this class is the substance known as **Plasmon.** It consists of the proteids of milk rendered soluble by combination with bicarbonate of soda. It occurs as a yellowish-white powder containing 12 per cent. of moisture, 8½ per cent. of ash and 11 per cent. of nitrogen (=69 per cent. proteid).

It is easily soluble in warm fluids, and is devoid of taste. It is absorbed very completely, only from 2 to 4½ per cent. being lost even when as much as 135 grammes were given daily. Metabolic experiments show that it is capable of replacing all other proteids in the food.[1] It is the cheapest of all the casein preparations.

In these forms casein is digested with ease and absorbed almost in its entirety, and is capable, if necessary, of replacing all other forms of proteid in the diet.[2] Added to this, casein presents some special advantages not possessed by other varieties of proteid. For one thing, it is readily capable of 'fixing' acids, and so neutralizing them. The power of casein in this respect is three times greater than that of an equal weight of beef.[3] This property gives it special advantages in those cases of dyspepsia in which too much acid is being poured into the stomach.

Another valuable peculiarity of casein is that it contains phosphorus, which is found also in the products of its digestion, and so enters the blood in an organic form,[4] rendering casein a valuable source of that essential constituent of all our tissues.

We have also seen that casein is incapable of yielding either sugar or uric acid by its decomposition, and its use is thus quite admissible in cases of diabetes and gout.

Lastly, casein is so easily and rapidly absorbed that it has but little opportunity of undergoing putrefaction in the intestine, even if it does not itself, as some have supposed, act as an intestinal antiseptic.[5]

In these forms casein is not clotted by rennet, but it is thrown down from its solution by the addition of acids in rather coarse flakes. It is better, therefore, to administer it mixed with other semi-solid foods, *e.g.*, gruels or thick soup, rather than by itself.

The nutritive value of these preparations is undoubtedly very high, containing as they do fully 90 per cent. of pure proteid. An invalid

[1] Ernst Bloch, 'Ueber das Plasmon' (Caseon), *Zeit. f. Diät. Ther.*, iii. 482, 1899. Plasmon is supplied by the Plasmon Syndicate, 56, Duke Street, Grosvenor Square, W.

[2] Röhmann, *Berlin. Klin. Woch.*, No. 24, 1895.

[3] Brandenburg, *Deut. Archiv. f. Klin. Med.*, lviii. 71, 1896.

[4] Salkowski, *Berlin. Klin. Woch.*, No. 47, 1894, and *Deut. Med. Woch.*, 1896, p. 225.

[5] See Salkowski, *loc. cit.*; Schmitz, *Zeit. f. Physiolog. Chemie*, xix. 378, 1894; and Laquer, *Verhandl. d. 16ten Cong. f. Inn. Med.*, p. 546, 1898.

does not require more than 80 grammes of proteid daily, and this quantity would be more than covered by 100 grammes (3½ ounces) of Nutrose at a cost of 1s. 8d.[1] That an amount almost equal to this can be administered daily for prolonged periods has been fully proved by clinical experiment.[2] An ounce of Nutrose (eight moderately heaped teaspoonfuls) yields as many Calories as two eggs,[3] but costs about three times as much. A rather large tumblerful of milk would yield the same amount of energy, and in a still cheaper form than eggs.

It is as a means of enriching the diet in proteid, however, rather than as sources of energy, that these preparations are specially valuable. Roughly speaking, one may say that one part of them is equal as a source of proteid to four parts of meat. Their tastelessness and solubility enables them to be added to other foods, such as soups, milk puddings, cocoa and jellies, raising greatly their nutritive value, and without the patient being able to suspect that any such addition has been made. In many cases of illness, and especially, perhaps, in fevers and diabetes, they increase very considerably our dietetic resources, and are probably destined to take an important place in the treatment of disease by feeding.

They are far superior to any meat preparation as condensed forms of proteid.

It should be added that casein preparations are not adapted for administration *per rectum*, and that disappointment will attend any attempt to administer them in that way.

[1] Nutrose costs 7s. 6d. per lb.; Eucasin, 5s. 6d.; Sanose, 14s.; and Plasmon, 2s. 6d. Pure casein in the form of Protene flour costs 4s.
[2] See Oppler, *Therap. Monatshefte*, April, 1897.
[3] One gramme of casein = 5·5 Calories (Rubner).

CHAPTER IX

CHEESE, EGGS, AND EGG SUBSTITUTES

CHEESE.

1. *Chemical Composition.*

CHEESE consists essentially of the casein and fat of milk. It may be prepared in one of two ways:

1. The milk may be allowed to clot under the influence of rennet. If pure milk be so treated, the resulting cheese will contain most of the fat—*e.g.*, Cheddar—and the proportion of fat may be rendered still greater by adding cream to the milk—*e.g.*, some forms of Stilton. In other cases part of the cream is removed by skimming. In that case the cheese will be proportionately poor in fat—*e.g.*, some Dutch cheeses.

2. The casein may be precipitated by allowing the milk to become sour, or by adding to it an acid, such as vinegar. Under these circumstances the casein carries down with it but little fat, and the cheese produced is a 'lean' cheese—*e.g.*, some Dutch and German cheeses.

The nature of the cheese will also depend on the kind of milk from which it is derived. In by far the majority of cases cow's milk is the source, but Parmesan is made from partly skimmed goat's milk, and Roquefort from the milk of the ewe. In whatever way the casein is obtained, it is next squeezed to remove the whey which is contained in it. If high pressure be employed at this stage, the resulting cheese is 'hard,' while a lower degree of pressure produces a 'soft' cheese.

The chief examples of **hard cheese** are these: Parmesan, Gouda, Edam, Chester, Cheddar, Roquefort.

Amongst the **soft cheeses** are the following: Brie, Camembert, Neufchâtel, Gorgonzola, Limburg, Stilton, and Cream.

The soft cheeses do not keep well, and are intended for immediate consumption.

After being submitted to pressure, the next step is to set the mass of casein and fat aside in a cool place to 'ripen.' This process is brought about by the agency of bacteria, and results in chemical changes in the casein which are not as yet perfectly understood. 'Amido bodies,' however, seem always to be produced, and a small amount of peptone. Whether or not the fat in the cheese increases at the expense of the casein is still disputed.

The flavour of the cheese undoubtedly depends on the particular species of germ which has found access to it during the ripening, each species producing definite chemical bodies, which give to that particular kind of cheese its peculiar characteristics. The process seems to be analogous to that which takes place in the manufacture of wines. By the use of different yeasts, one can produce from the same grape-juice wines of entirely different character and bouquet. So with cheese. By the use of different bacteria one should be able to produce from the same casein cheeses of quite dissimilar flavour. No doubt that is what will happen in the future. At present cheese-making is a rule-of-thumb process. By-and-by it will become a science. It has already begun to be so, indeed, in Germany, and even in some parts of England. The cheese-maker of next century will have a laboratory attached to his factory, in which pure cultures of the bacteria responsible for the flavour of each variety of cheese will be nursed, and instead of 'Stilton' coming from one district, 'Gorgonzola' from another, and 'Gruyère' from a third, all will be produced under one roof. We may look forward then, perhaps, to tasting cheeses hitherto unknown, and to combinations of flavour as yet unsuspected. We may combine the virtues of Stilton with Gorgonzola, or those of Gruyère with Roquefort, for the artist of the palate will have in his hands the precise instruments of science.

Whether this forecast be ever verified or not, there is little doubt that the gross chemistry of cheese will never be much altered. It must always remain, for all practical purposes, a compound consisting essentially of proteid and fat. In the accompanying table there is shown the average composition of some of the leading cheeses met with in the market:

COMPOSITION OF CHEESES.[1]

Cheese.	Water.	Nitrogenous Matter.	Fat.	Ash.	Average Cost per lb.	Real Cost of 1 lb. of Nutriment.
American	26·9	32·9	31	4·5	6d.	8⅕d.
Brie[2]	49·7	18·9	26·8	4·5		
Camembert ..	48·6	21·0	21·7	4·4	11 oz., 6d.	8⅘d.
Cheddar	31·9	33·4	26·8	3·9	9½d.	1s. 2d.
Cheshire	33·2	29·4	30·7	4·3	9½d.	1s. 2d.
Cream	32·0	8·6	35·9	1·5		
Dutch	32·9	30·8	17·8	6·3	7d.	10⅗d.
Gloucester ..	31·9	36·7	24·7	4·4	9½d.	1s. 2d.
Gorgonzola ..	39·2	25·9	26·9	4·7	9d.	1s. 3d.
Gruyère	34·1	31·5	28·2	4·0	10d.	1s. 3d.
Neufchâtel ..	41·0	14·3	43·2	1·4		
Parmesan ..	30·0	43·8	16·5	5·9	11½d.	1s. 4⅘d.
Roquefort ..	25·1	34·8	31·5	5·5	1s. 1½d.	1s. 6d.
Stilton	27·6	23·9	38·9	3·1	1s. 2d.	1s. 7d.

Taking the results as a whole, one will not be far wrong in regarding cheese as made up of one-third of water, one-third of nitrogenous matter, and one-third of fat. It is well to remember, however, that there is no inconsiderable amount of mineral matter present as well, consisting chiefly of salts of lime, and that some cheeses at least may contain as much as 2 per cent of milk-sugar.

The 'nitrogenous matter' consists mainly, but by no means entirely, of proteids. Stutzer has estimated the different forms in which nitrogen occurs in Camembert, with the following results:[3]

Total N	=2·9	per cent.
N as ammonia	=0·386	„
„ amides	=1·117	„
„ albumoses and peptone	=0·885	„
„ casein and albumin	=0·397	„
„ indigestible forms ..	=0·115	„

The exact proportions of these different nitrogenous bodies will naturally vary considerably in different cheeses, but it is well to note the large amount of non-proteid nitrogen present, which must be allowed for in an estimate of the nutritive value of cheese.

2. *Digestibility.*

The infiltration of cheese with the fat which it contains must always render it an article of diet not easily dealt with by delicate stomachs, for the fat forms a waterproof coating, which prevents the access of the digestive juices to the casein.

[1] These figures are constructed by taking the averages of the analyses collected by Pearmain and Moor. Prices are those of the Stores.
[2] König.
[3] *Zeit. f. Analyt. Chem.*, 1896, p. 493.

The larger the lumps of cheese which reach the stomach, the slower will this access be. Hence the importance of reducing the cheese to a state of fine division before it is swallowed. This may be done by careful chewing. Now, it is more easy to pulverize a hard morsel than a soft one, for the latter tends always to elude the teeth. For this reason, a piece of hard, dry cheese is more easily digested than a soft and moist piece. A better plan, however, is to break up the cheese before it is eaten at all. This may be done by grating, but a better way is to dissolve the cheese, and then mix it through some other form of food. An able writer[1] on the chemistry of cookery has pointed out that this may best be done by means of bicarbonate of potash. It was pointed out, when speaking of the chemistry of casein, that it forms soluble compounds with alkalies. Bicarbonate of potash is an alkali, and it seems to combine with the casein of the cheese, and brings the latter into a soluble state. As much bicarbonate of potash as will lie on a threepenny piece is sufficient to dissolve a quarter of a pound of cheese if the latter be first grated or chopped up into fragments. By the addition of milk and eggs, a very savoury and exceedingly nutritious pudding or *fondu* can be prepared, and at a very small cost. It is certainly much to be wished that we should avail ourselves more frequently of such a method of cooking cheese in this country. If cheese is ever to take the place that it ought to have as a cheap and convenient form of proteid food, some such method must be employed, for it is the difficulty with which cheese is digested that renders it an impossible food to many persons.

Another reason, probably, for the disagreeable effects which cheese is apt to produce in the stomach is that in the process of ripening small quantities of fatty acids are produced, and these are always very irritating. The addition of an alkali in the solution of the cheese will neutralize these, and render them less harmful.

It is only in the stomach that the difficulty of digesting cheese occurs; once in the intestine, it is absorbed as easily and completely as meat.

3. *Nutritive Value.*

Of the high nutritive value of cheese there can be no doubt. It is just what one would expect when one remembers that a pound of, say, Cheddar cheese represents the total casein and most of the fat in a gallon of milk.

[1] Mattieu Williams.

The average amount of moisture which cheese contains is 33 per cent., the remainder being made up of proteid and fat in varying, but on the whole fairly equal, proportions. The amount of water in moderately lean beef is about 73 per cent., the remaider being also made up of proteid and fat, the former always largely predominating.

Beef, then, contains less than half as much nourishment as the same weight of cheese. Williams goes further than this, and asserts that a cheese of 20 pounds contains as much nutriment as a sheep's carcase of 60 pounds.

If one appeals to the standard of the Calorie, the verdict is the same. A pound of cheese yields fully 2,000 Calories of energy, which is more than three times the amount yielded by a pound of moderately lean beef. When one adds to these considerations the fact that a pound of cheese can be obtained at about one-sixth of the cost of 3 pounds of beef, which is its nutritive equivalent, it is at once evident that we possess in cheese a substitute for meat which should be of the greatest value in poor households.

But if cheese is thus to become a cheap substitute for meat, it is of the greatest importance what variety of cheese is bought. For it is true of cheese in an even greater degree than of most other foods, that in buying it we pay for flavour, not for food value. The above table shows the real cost of one pound of nutriment as one obtains it in the standard brands of cheese. By the real cost one means what one pound of the proteid and fat contained in the cheese would actually cost if all the water were excluded.

The table brings out some interesting points. It shows, for example, that American (Canadian) cheese contains rather more nutriment than the same quantity of Parmesan, and at one-half the price. Stilton, again, costs twice as much as American, and contains about the same proportion of real food. To those who eat cheese simply for the sake of its flavour, and append it as a savoury to the end of an ample meal, these considerations are, of course, of no interest. But to the man who wishes to use cheese as a cheap and efficient substitute for meat one would say, Buy Canadian or Dutch, and preferably the former; for in that way you will be getting much the most nutriment—in other words, much the most muscle and blood and brain—for the money you spend.

Eggs.

An egg is an undeveloped chick. This may sound a truism, but t is the key to the right understanding of the value of eggs as food. For if the chick is developed from the egg without the aid of any

external agency save heat, it follows that the egg must contain within itself all the building material necessary for the making of the chick, along with such a supply of nutriment as the latter requires until it is ready to be hatched. It may be said of eggs, indeed, that they are veritably

> 'Treasure-houses, wherein lie,
> Locked by angels' alchemy,
> Milk and hair and blood and bone.'

In chemical language they must contain much proteid and mineral matter (especially salts of lime, phosphoric acid, and iron), for these are the only materials out of which 'blood and bone' can be built up. They are likely, also, to contain fat, for that is the most compact form in which nutriment for the young chick can be stored. And, as a matter of fact, it is practically of these constituents that an egg consists. Carbohydrate it need not contain, for the chief use of carbohydrate is, as we have seen, to serve as a source of muscular energy; and in the narrow confines of an eggshell muscular movement is impossible.

Passing on to details, it may be said that a hen's egg of average size weighs about 50 grammes (2 ounces), the weight being distributed as follows:

Shell	12 per cent., or	6 grammes
White	58 ,,	29 ,,
Yolk	30 ,,	15 ,,

The **shell** consists almost entirely of carbonate of lime. As the process of hatching goes on it becomes much thinner by absorption, and one might think that it was used as a storehouse of lime which is drawn upon for the formation of the bones. But apparently this is not so. The egg seems to contain in itself enough lime for the purpose.[1]

The **white** consists of a solution of proteid shut up in the interior of millions of cells. When white of egg is beaten up, the walls of the cells are ruptured, and the proteid escapes. The digestibility of the egg-white is thereby increased, for the walls of the cells offer a slight barrier to the digestion of the proteid which they contain.

The proteid of egg-white is called 'egg albumin.' It would be an error, however, to regard it as a single substance. It seems to consist of a mixture of different proteids, some of which are of a compound nature, and contain a carbohydrate group in their molecule.[2] This has some bearings on the use of eggs as a food for diabetics, which will be pointed out later.

[1] See Voit in 'Hermann's Handbuch,' Bd. vi., p. 459, footnote.
[2] See Eichholz, *Journ. of Physiol.*, xxiii. 163, 1898.

The yolk is the storeh-use of nutriment for the young chick, and consequently has a very different composition from the white. It contains much less water and more solid matters, amongst the latter being a large proportion of fat. The general composition of the white and yolk is contrasted in the following table (König), and graphically illustrated in the accompanying diagrams (Figs. 9, 10):

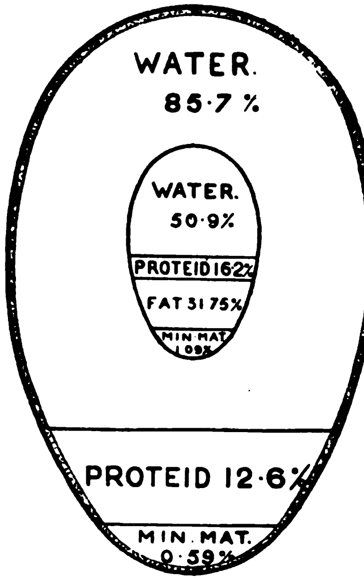

FIG. 9.—PERCENTAGE COMPOSITION OF THE WHITE AND YOLK OF AN EGG.

	Water.	*Proteid.*	*Fat.*	*Other Non-nitrogenous Matter.*	*Mineral Matter.*
White ..	85·7	12·6	0·25	—	0·59
Yolk ..	50·9	16·2	31·75	0·13	1·09

One can see at a glance that the yolk of the egg is much its most nourishing part. The complexity of the composition of the yolk is shown by the following more detailed analysis of its constituents[1]:

1. Water	51·8	per cent.
2. Proteids { vitellin	15·8	"
nuclein	1·5	"
3. Fats (palmitin, stearin, and olein)	20·3	"
4. { Cholesterin	0·4	"
Lecithin	7·2	"
Glycerin-phosphoric acid	1·2	"
5. Cerebrin	0·3	"
6. Colouring matter	0·5	"
7. Mineral matters	1·0	"

[1] Gobley, quoted by Röttger, 'Lehrbuch der Nahrungsmittel Chemie,' p. 105. See also Juckenack, *Zeit. f. Untersuch. d. Nahrungsmittel*, Bd. xii., p. 905, 1899.

These different constituents are not merely mixed up in the yolk, but are to a large extent actually combined with one another, producing complex bodies which chemists have not yet entirely succeeded in unravelling.

Of the proteids present, the nuclein[1] alone calls for remark. It is of importance in that it contains phosphorus in organic combination.

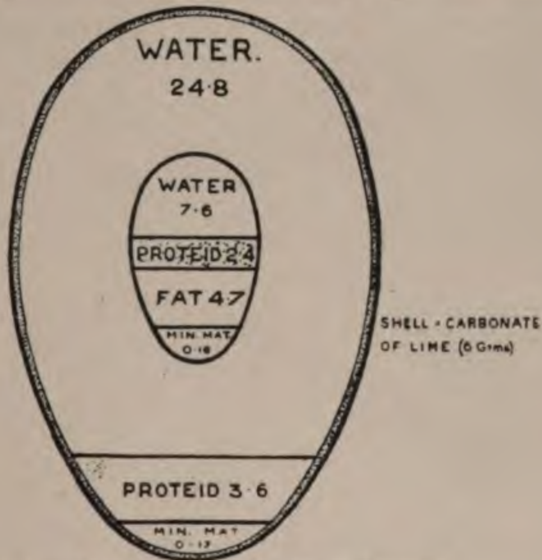

FIG. 10.—ACTUAL COMPOSITION OF AN AVERAGE EGG WEIGHING 50 GRAMMES.

Some of it appears also to be united to iron in a compound to be described immediately.

The third group of constituents—palmitin, stearin, and olein—are simply fats, such as we have already encountered in butter, and have the same nutritive value as these. Their presence in the form of an emulsion in the yolk makes them very easily digested.

In the fourth group are classed together a number of substances

[1] It is doubtful whether the nuclein in yolk of egg is really true nuclein or merely a paranuclein. The point is of importance for this reason, that true nuclein is a source of uric acid, and if present in yolk of egg the latter should be avoided in gout. Some observers deny that yolk of egg increases the output of uric acid (Hess, *Archiv. f. Exper. Path. und Pharmak.*, xxxvii. 243, 1896). Haig, however, maintains that eggs cause an increased excretion of uric acid ('Uric Acid,' 4th edit., p. 613). He says: 'I gradually eliminated from my diet all articles that contained even the smallest quantities of egg . . . as I got very distinct evidence that these when taken every day decidedly increased the excretion of uric acid.'

which are of great interest, and give to the yolk of egg much of its peculiar value as a food. They are often included among the fats of the yolk for the reason that, like these, they are dissolved out by ether; and in the table on p. 148, in which the general composition of the yolk is contrasted with that of the white, they are so included. They are, however, very different, chemically, from ordinary fats. They are chiefly characterized by containing a large amount of phosphorus in a form in which it is readily absorbed and appropriated by the body.[1] For this reason these substances are sometimes termed phosphatides.[2]

Cerebrin is a glucoside found chiefly in nervous tissues. Its nutritive value is unknown.

The most important of the mineral matters are phosphoric acid, lime, and iron. According to König, 100 parts of the ash of the white and yolk of egg have the following composition respectively:

Composition.	*Yolk.*	*White.*
Potassium	9·29	31·41
Sodium	5·87	31·57
Lime	13·04	2·78
Magnesium	2·13	2·79
Oxide of iron	1·65	0·57
Phosphoric acid	65·46	4·41
Sulphuric acid	—	2·12
Fluorine	0·86	1·06
Chlorine	1·95	28·82

The **phosphorus** of the yolk is, as we have seen, almost entirely present as an organic compound. The same is true of the **iron**, which is probably united with nuclein.[3] Now, it appears to be a rule in physiology that mineral matters are most easily absorbed when they form part of an organic compound. Hence, the iron in the yolk of egg easily enters the blood, and it has been found[4] that dogs fed largely on yolk of egg excrete far more iron in the urine than when they are placed on ordinary diet. One hundred grammes of yolk of egg contain 0·01 gramme of iron,[5] and as the yolk of one egg weighs 15 grammes, it will yield 0·0015 gramme of the metal.

[1] Hasebroek has shown (*Zeit. f. Physiolog. Chemie*, xii. 148, 1888) that lecithin is split up in the intestine into fatty acids, cholin and glycerin-phosphoric acid. The former are saponified and acquire the value of ordinary fats; the cholin is split up into gases, and the glycerin-phosphoric acid is absorbed unchanged. Cholesterin is probably of no nutritive value, but lecithin appears to favour the growth of young animals (*Maly's Jahres Bericht*, p. 615, 1897).

[2] See Thudichum's 'Spirit of Cookery,' p. 589.

[3] The compound is sometimes termed a 'hæmatogen,' because from it the colouring matter of the blood of the chick seems to be formed.

[4] Bunge.

[5] Socin, *Zeit. f. Physiolog. Chemie*, xv. 93, 1891.

Assuming that 10 milligrammes of iron are required by the human body daily (Stockman), seven and a half eggs will suffice for the supply of that important constituent of the blood. Yolk of egg must, therefore, be regarded as a useful food for anæmic persons.

The abundance of **calcium** in the yolk is very striking. No food contains so much of it except milk. It is probable that most of these lime salts are also present in organic combination, *i.e.*, in a very assimilable form.

The great richness of yolk of egg in fat, in lime salts, and in organic compounds of phosphorus and iron, make it a peculiarly valuable food for young infants, especially those which are suffering from rickets, for it is just these very compounds which a child needs, and a rickety child needs them most of all.

The **composition of the whole egg** may be summed up as follows:[1]

Shell	11·2 per cent.
Water	65·5 "
Nitrogenous matter	13·1 "
Fatty matters	9·3 "
Ash	0·9 "

The composition of the *edible* part (white and yolk together) may be compared with that of meat thus:[2]

	Egg.	*Moderately Lean Meat.*
Water	73·7	73·0
Proteid	14·8	21·0
Fat	10·5	5·5
Ash	1·0	1·0

One sees at a glance that eggs contain almost the same total of nutritive matter as meat, but are relatively richer in fat and poorer in proteid.

Eggs are thus admirably adapted chemically to supplement a food rich in carbohydrate, moderately rich in proteid, but poor in fat. Such a food is found in rice and many cereals, and the addition of eggs to these in the form of puddings makes a complete food. We have here another instance in which ancient experience and practice is justified by modern science.

The composition of a goose's or duck's egg is similar to that of the hen, but, of course, they are larger. An average duck's egg weighs about 70 grammes, a goose's egg about 130 to 150 grammes.

When kept, eggs gradually lose water by evaporation and become lighter. A fresh egg should sink at once in a 10 per cent. salt

[1] Atwater, 'Composition of American Food Materials,' Bulletin 28, United States Department of Agriculture (revised edition). The percentage of shell is somewhat lower than that given on p. 147.

[2] Atwater, 'Composition of American Food Materials,' Bulletin 28 (average of sixty analyses).

solution (about 2 ounces to a pint), but the longer it has been kept the nearer the surface it will float.

When an egg becomes **rotten**, alkaline sulphides are produced, apparently from the white, and these being acted upon by phosphoric acid derived from the yolk, sulphuretted hydrogen is liberated, which gives to a rotten egg its very disagreeable smell. If an egg is boiled for a long time the same effect is produced in a minor degree, and it is well known that an egg so treated is apt to have a slight odour.

The **digestibility of eggs** in the stomach depends largely upon the form in which they are taken. Some experiments have been made on a healthy man which throw light on this subject.[1] Two eggs were given, cooked in different ways, and portions of the stomach contents were withdrawn at intervals, the time being noted at which any portion of egg ceased to be recovered. The results were as follows:

2 eggs lightly boiled have left the stomach in	1¾ hours
" raw have left the stomach in	2¼ "
" poached + 5 grammes of butter have left the stomach in ..	2½ "
" hard boiled have left the stomach in	3 "
" as an omelette have left the stomach in	3 "

The figures speak for themselves. One or two points, however, call for comment. It is surprising to find that lightly boiled eggs are more quickly disposed of by the stomach than eggs given raw. One must take care, however, not to jump to the conclusion that lightly boiled eggs are more suited to a stomach requiring rest than raw eggs are. As a matter of fact, raw egg seems to be scarcely digested in the stomach at all, but passed on out of it to a large extent unchanged. Some observations bearing upon this point were made on a patient in whom, as the result of disease, an artificial opening had formed into the intestine a very short distance below the point at which it joins the stomach.[2] It was found that when raw egg was given by the mouth more than half of it ultimately escaped by this opening unchanged. The explanation may perhaps be that raw egg is such a bland fluid that it does not excite the secretion of gastric juice nor the movements of the stomach. Hence it may linger longer in the stomach than an egg which has been lightly boiled, because the solid particles of the latter stimulate both secretion and movement. The raw egg is thus really the less irritating to the stomach of the two, and makes less demand upon it, for its digestion is really performed in the intestine.

[1] Penzoldt, *Deut. Archiv. f. Klin. Med.*, Bd. 51, p. 535, 1893.
[2] Busch, *Virchow's Archiv.*, Bd. 14, p. 140, 1858.

The difference in digestibility between hard and soft boiled eggs depends to some extent, also, on the degree to which the former are subdivided. If finely chopped up, they could probably be disposed of as easily as the soft-boiled eggs.[1]

I am not acquainted with any experiments on the relative digestibility of the white and yolk of egg, but one would expect the latter, owing to its larger proportion of solids and great richness in fat, to be more slowly dissolved in the stomach than the white.

It must also be pointed out that **idiosyncrasy** plays a large part in the digestion of eggs. Some persons are unable to swallow even a small particle of egg without becoming violently ill. Apparently their digestive juices act on the egg in such a way as to produce poisons from it.[2] In other cases sulphuretted hydrogen seems to be produced during the digestion of the egg. As the table on p. 150 shows, the sulphur of the egg is confined almost entirely to the white. That part should, therefore, be specially avoided in such conditions.

The **absorption** of eggs in the intestine seems to be very complete. It has been found that even when 21 hard-boiled eggs are taken daily they are absorbed as completely as meat, only 5 per cent. of the dried substance being lost.[3]

Eggs, therefore, leave a very small residue in the intestine. This, coupled with the fact that they contain so much lime, may perhaps explain the constipating effect of eggs on some persons.

Chemical considerations have shown us that the **nutritive value of eggs** is due almost entirely to proteid and fat. One egg contains enough of these to yield 70 Calories of energy. Half a tumblerful of good milk or 1½ ounces of fat meat would yield about as much.

Roughly speaking, 15 to 20 eggs may be taken as the nutritive equivalent of 2 pounds of medium fat meat. A good hen will produce 250 to 300 eggs a year, which would be equal, as a food, to 40 pounds of meat, or two-thirds of the carcase of a sheep.

The absence of carbohydrates prevents eggs from being in any sense a complete food, and it would require 20 of them a day to supply even the amount of nitrogen required by a healthy man. They cannot be regarded as a *cheap* source of proteid (see p. 16), though the convenient form in which their nutritive constituents are presented, and the readiness with which they lend themselves to the

[1] A great many observations have shown that the white of one egg finely chopped and taken with 2½ ounces of water remains in the stomach for one and a quarter hours (Jaworski and Gluzinski, *Zeit. f. Klin. Med.*, xi. 84).

[2] For an illustrative case, see *Med. and Surg. Review*, ii. 299.

[3] Rubner, *Zeit. f. Biologie*, Bd. 15, p. 115, 1879.

art of the cook, must always render them a most useful form of food. In addition to these considerations, the peculiar chemical composition of the yolk causes that part of the egg to be a valuable source of phosphorus, lime and iron, of which advantage may well be taken in the dietetic treatment of certain diseases, more especially of early life.

There are but few artificial preparations of eggs. **Ovo** consists of eggs dried at a low temperature,[1] so that they are capable of being redissolved. It contains 90·5 per cent. of solids, and 4·1 per cent. of ash. It is put up in packets, the contents of each of which weighs 12 grammes, and represents one egg. It is a convenient form in which to keep eggs for cooking purposes. Dried eggs are also prepared in a very similar way by the Gye process (see p. 160). There is nothing really novel in these preparations, for a method of drying eggs was described as long ago as 1871.[2] The white of egg is also sold in a dry form,[3] and is used chiefly for making confectionery.

Custard-powders are sold as 'substitutes' for eggs. The majority of them consist chiefly of starch, to which a yellow colour is imparted by mixture with some vegetable dye—*e.g.*, turmeric. The following analyses of some of them were published in *Food and Sanitation* (November 25, 1893):

	Bird's Custard-powder.	Goodall's Custard-powder.	Goodall's Egg-powder.	Borwick's Egg-powder.	Yeatman's Egg-powder.	'Model Egg-powder.
Starch	86·25	84·45	51·03	26·38	52·32	53·82
Albuminous compounds	0·59	0·58	6·01	2·96	6·00	5·06
Soluble colouring matter	0·88	0·90				
Baking soda	—	—	15·33	50·70	22·11	26·71
Tartaric acid	—	—	13 69	10·33	11·37	6·19
Phosphates	—	—	0·24			
Carbonates of lime and magnesia	—	—	2·70			
Chlorides and sulphates	—	—	—	—	—	traces
Water	11·83	13·69	11·0	9·63	8·20	8·22
Ash	0·45	0·38				
	100·00	100·00	100·00	100·00	100·00	100·00

It is obvious that they have nothing in common with eggs except a yellow colour, and that their nutritive value can be in no way equal to that of a genuine custard.

[1] The Mecredy Manufacturing Syndicate, Limited, 248, Gresham House, E.C.
[2] *Compt. Rend.*, lxxii. 106.
[3] Nurdin and Peacock, Wells Street, Oxford Street, W.

CHAPTER X

VEGETABLE FOODS

THE foods with which we have been dealing up till now are derived from the animal kingdom. In the present chapter we approach the study of that large and varied class of foods which we obtain from vegetable sources. We may consider in the first place, in a general way, the chemical composition, digestibility and nutritive value of the vegetable foods as a whole, contrasting them in these respects and in their economic aspects with foods of animal origin, and then subsequently proceed to the detailed study of the different groups into which vegetable foods may be subdivided.

1. CHEMICAL COMPOSITION OF VEGETABLE FOODS.

From a chemical point of view, the most striking feature of the vegetable foods is the large proportion of carbohydrates which they contain. This peculiarity marks them off at once from the animal foods, for the latter, with a few exceptions, such as milk, contain little or no carbohydrate at all. Richness in proteid and fat is the characteristic of animal foods, abundance of sugar and starch that of the products of the vegetable kingdom.

Now, starch is by no means such a concentrated form of carbon as fat is. Indeed, it takes 221 parts of starch to be equal to 100 parts of fat. This is one reason why vegetable foods must be regarded as dilute and bulky, while animal food is concentrated and compact.

But vegetable foods possess not merely abundance of carbohydrates: they contain proteids and fats as well. Some members of the class, such as the pulses, are peculiarly rich in the former; others, such as nuts, in the latter; but of vegetable foods as a whole it may be said that they tend more than the animal foods to contain representatives of all the three groups of nutritive substances. In consider-

ation of this fact, the vegetable kingdom must be pronounced a better source of human food-supply than the animal, and if one were confined in his selection of a dietary exclusively to one kingdom or the other, it would be wiser to patronize the miller and greengrocer rather than the butcher and fishmonger, for it is undoubtedly possible to live on vegetables alone, whereas it is difficult to live for any length of time on nothing but meat. The better way for most people, however, is to avail themselves of the resources of both kingdoms.

It is now necessary that we should consider for a moment in somewhat greater detail the different groups of nutritive substances which enter into the composition of the vegetable foods.

Of the **carbohydrates** we have already mentioned sugar and starch. Sugar is the form in which carbohydrate circulates in plants; starch is the shape in which it is stored up. If a plant has manufactured more carbohydrate than it requires for its present purposes, it puts aside the surplus in the shape of starch, and when the pinch of need comes upon it, and it requires a supply of carbohydrate again to maintain its life, some of this store of starch is changed back into sugar by the help of the ferment diastase, and circulates once more throughout the plant. Sugar, then, is the soluble form of carbohydrate: it is carbohydrate in circulation, and corresponds to the current coin in our pocket; starch is the insoluble form of carbohydrate: it is carbohydrate in reserve, and corresponds to the bullion in the bank. It is important to grasp this mutual convertibility of starch and sugar. We shall see later that a precisely analogous process goes on in the animal body, and that all the starch which we eat must first be converted by digestion into sugar before it can circulate through our bodies and be available as food.

A heap of **starch** is really made up of minute grains, just as a heap of sand is, but the starch grains are much smaller than those of sand, and can only be seen with the aid of a microscope. When so examined, they will be observed to have various shapes, round, oval or polyhedral, depending on the plant from which the starch is derived. They also exhibit concentric markings. These indicate that the starch grain is built up, like a sandwich, of different layers. One set of layers consists of true starch (amylose or granulose); the other set consists of a form of cellulose, formerly known as starch cellulose or farinose. The outer layers of the starch grain are the densest, and the most external one of all seems to consist entirely of starch cellulose.

These little starch grains are not dissolved by cold water. This

is one reason why starch is the form in which plants stow away their surplus carbohydrate; being insoluble, there is no risk of its being all washed away by rain if the plant gets injured. Another reason is that starch is a more concentrated form of carbohydrate than sugar, and packs into a smaller bulk.

If boiling water be poured on the grains, they swell up and burst, and the true starch escapes from between the layers of cellulose, and forms with the water the gelatinous solution familiar to the laundress.

It is this rupture of the starch grains that we seek to bring about by the cookery of vegetable foods, for one can readily imagine that starch grains which have been thus broken up and brought into solution will be much more easily attacked by the digestive juices, and converted into sugar, than when eaten in their raw and unruptured state.

If starch be subjected to dry heat, it undergoes a modification by which it becomes soluble in water, and is ultimately converted (at a temperature of about 300° F.) into the form of carbohydrate known as **dextrin**. This is a gummy substance, and is familiar to everyone as the sticky material on the backs of postage stamps. This change also takes place to some extent in cookery. The crust of a loaf of bread, for example, consists mainly of starch which has been converted by the heat of the oven into soluble starch and dextrin.

We saw that in the case of meat the nutritive ingredients (proteids) were contained in minute tubes held together by a connective tissue which yields gelatin. In the case of most vegetable foods, on the other hand, the chief nutritive ingredient (starch) is contained in a vast number of minute compartments, more or less cubical in shape, and collectively known as 'cells.' The walls of these and the framework which holds all the cells together are composed of a substance known as **cellulose**, the most familiar form of which is paper.

Now, cellulose also belongs to the carbohydrate group, but it is especially characterized by its extraordinary insolubility. Neither cold nor hot water has any effect upon it, and in order seriously to influence it one must boil it with a dilute acid. In its old age cellulose gets infiltrated with resinous matter and becomes wood; it is then past the stage of being much affected, even by acids. The presence of cellulose in nearly all forms of vegetable food is a fact of great practical importance when one considers that it encloses the starch grains in the vegetable cell, much in the same way as a sheet of brown paper encloses a parcel of oranges, and when one remembers its peculiar insolubility it becomes obvious at once that this wall of

cellulose must present a great obstacle to that penetration of the nutritive ingredients by the digestive juices which is of the first importance for the proper carrying out of digestion.

In addition to starch and cellulose, there is another and peculiar group of carbohydrates met with in vegetable foods, the members of which are spoken of by some writers as **pectin bodies**, while others class them together under the general term 'pectose.' These are the substances which give to fruits their power of forming jellies when boiled, and little is known of their exact chemical nature, but they appear to be converted into a special kind of sugar when digested (pentose), which is at least partly assimilable by the body.[1]

The last group of carbohydrates which occur in vegetable foods are the **sugars** of which brief mention has already been made. Their importance as foods is such as to merit a more detailed consideration later (see Chap. XV.).

The **nitrogenous substances** met with in vegetable foods may be divided, as in the case of meat, into those which are proteids and those which are not. The vegetable proteids belong mainly to the globulin class. These are easily dissolved by water containing a little salt, and may be lost to an appreciable extent from vegetables which are left soaking in such a mixture. It should be mentioned, also, that vegetable foods seem to contain less of the substances known as nucleo-proteids than one meets with in animal tissues. The practical importance of this will be pointed out when we come to consider the dietetics of gout.

The vegetable proteids are further distinguished from those of animal origin by being relatively poorer in carbon and richer in nitrogen, a fact which, as we shall see presently, may have an appreciable bearing upon our estimate of the relative nutritive value of the two. Both varieties of proteid, vegetable as well as animal, are coagulated by heat, and both are rendered less digestible thereby. The broad result of this is that cooking diminishes the digestibility of animal foods, because they are mainly composed of proteid, but raises the digestibility of vegetable foods because the latter contain, as a rule, very little proteid along with much starch, and cooking, as we have seen, renders starch much more easy of digestion.

[1] Some of these bodies appear to be of the nature of dextrins, whilst others, perhaps, stand nearer to starch. It might be well to restrict the term 'pectins' to the former group; they probably bear the same relation to the pentoses, or sugars with five carbon atoms, that dextrin does to the six-carbon-atom sugar, dextrose. The other group may be spoken of as pentosanes. The sugars to which they give rise are also found in many ripe fruits, and are certainly not easily assimilated by the cells of the body, and are apt to appear in the urine if the fruits containing them are eaten in excess.

Vegetable foods resemble animal foods in containing a large number of nitrogenous substances which are in no sense proteids. None of these, however, corresponds in any way to the 'albuminoids' (*e.g.*, gelatin) met with so abundantly in the animal kingdom.

On the other hand, **extractives** are well represented. Most of these belong to the group of chemical substances called 'amides.' Asparagin, which is richly present in the potato, is one of the best known. Its uses as an ingredient of the food will be considered when we deal with the potato.

Of the **fats** found in vegetable foods little need be said. They resemble in chemical composition the animal fats, but appear to contain, as a rule, more of the oily constituent (olein) and less of the more solid components (stearin and palmitin) than the fat of animals. Hence they tend to have the consistency of oils rather than of solid fats. This, however, increases rather than lessens their digestibility, while their nutritive value seems to be fully equal to that of the more solid animal fats.

The remaining chemical constituents of vegetable foods are *water* and certain *mineral salts*. There is an extraordinary amount of **water** present, much more than one is inclined to fancy. Even green peas and lentils, which are the richest in solid constituents of the commoner vegetable foods, contain 78 per cent. of water, while in green vegetables and most fruits water accounts for more than 90 per cent. of the weight of the fresh food. This means that a cabbage is really a more watery form of food than milk, for the latter only contains 87 per cent. of water. The apparent solidity of green vegetables is deceptive, and is merely due to the framework of cellulose which supports them.

This wateriness of most vegetable foods is one of their most essential properties, and is largely responsible for the low nutritive value of many of them when compared with the largeness of their bulk. Unfortunately, also, most vegetable foods become even more watery when subjected to the process of cooking; their last state is thus worse than their first, whereas in the case of animal foods the contrary is the case.

Attempts have been made, and with a large amount of success, to **reduce the bulk of vegetable foods** by removing the water which they contain. As early even as the middle of this century a patent was taken out, by a certain Mr. Masson, for effecting this by a process of drying. His method enabled him to put up 70 pounds weight of cabbage in a tin of 11 pounds. In recent years several processes

effecting the same object have been introduced,[1] with the result that one can obtain all the commoner vegetable foods in a remarkably compact form, and yet without the sacrifice of any of their nutritive ingredients or flavour. The conveniences of this in the case of military transport, camping expeditions, etc., are obvious.

The **mineral constituents** of vegetable foods are numerous and important. Further reference will be made to them when the different groups of vegetable foods are dealt with separately, but at present one may point out that potash is in most of them more abundantly represented than soda. This has been alleged by a distinguished physiologist (Bunge) as the reason why herbivorous animals have a craving for sodium in the form of common salt (sodium chloride).

A large proportion of the bases amongst the mineral ingredients of vegetable foods are united with organic acids, and these, when burnt up, either outside or inside the body, yield alkaline salts. The excretion of these in the urine causes the latter to have a less degree of acidity in vegetable than animal feeders, and is, as we shall see, turned to therapeutic account in the case of those who are suffering from stone or gravel.

2. Digestibility and Absorption of Vegetable Foods.

1. *In the Stomach.*—As a class, vegetable foods are not to any large extent really digested in the stomach. This is owing to the fact that starch, their chief ingredient, is entirely unaffected by the gastric juice. Hence it follows that it is only those vegetable foods which are particularly rich in proteid, such as the pulses, which throw upon the stomach any large share of the *chemical* part of their digestion. On the other hand, the manipulation of bulky vegetable food, its reduction to a state of fine division, and the passing of it on into the intestine, all entail upon the stomach a large amount of mechanical effort. As a consequence of this, one finds that animal food, which necessitates for its digestion more chemical but less mechanical work on the part of the stomach, is really better borne by persons of enfeebled digestive power than the majority of vegetable foods are.

2. *In the Intestine.*—It is customary to state that vegetable foods are less completely digested and absorbed in the intestine than

[1] Dried and compressed vegetable foods can be obtained from the Gye Process Fresh Food Co., 2, Gresham Buildings, Basinghall Street, E.C.; the Military Equipment Stores, Waterloo Place, S.W.; the Portable Food Co., St. George's House, Eastcheap; the British Preserving Co., Rayne, Essex.

animal foods. Stated in such general terms, the proposition cannot be substantiated. It depends entirely on the form of vegetable food. A glance at the table will show that the foods which are the most completely digested and absorbed of all (white bread, macaroni, and rice) are vegetable foods, while meat and eggs rank distinctly after these.

RELATIVE ABSORPTION OF SOME ANIMAL AND VEGETABLE FOODS.[1]

Food.	*Dry Substance not Absorbed.*
White bread	4 per cent.
Macaroni	4 "
Rice	4 "
Meat	4½ "
Eggs	4½ "
Maize	7 "
Milk	9 "
Peas	9 "
Potatoes	11 "
Black bread	15 "
Cabbage	15 "
Turnips	20 "

Two factors appear to determine the digestibility of vegetable foods in the intestine. The first is their bulk; the second is the amount of cellulose which they contain. If the bulk be small and the proportion of cellulose scanty, digestion is very complete. White bread, macaroni, and rice fulfil these conditions, hence the small proportion of them which escapes absorption. On the other hand, if the food be bulky and full of cellulose, digestion and absorption are much less perfect. Unfortunately, the majority of vegetable foods more or less correspond to this description, and hence the proposition as originally laid down is true of the majority of them, namely, that they are not so completely digested and absorbed as animal foods are.

The property of bulkiness is one common to the majority of vegetable foods. As already indicated (p. 159), it is to be attributed in a great measure to the amount of water and starch which they contain. Considering that upwards of four-fifths of the weight of all green vegetables and fruits is due to water, and that even the drier forms, such as split peas, take up about three times their weight of water in the process of cooking,[2] it is not to be wondered at that vegetable foods must be bulky out of all proportion

[1] Compiled from the figures of Voit, *Zeit. f. Biolog.*, Bd. 25, p. 232, 1889.
[2] Half a pound of split peas boiled to a thick porridge weighs 2 pounds.

to the amount of nutriment which they contain. To this rule bread is almost the sole exception, containing as it does fifty-six parts of dry matter in every hundred. Hence, bread must of necessity enter largely into any purely vegetarian diet if the bulk of the latter is to be kept within reasonable limits. Even then a vegetable diet remains of much larger volume than a purely animal or even a mixed diet. The difference is graphically brought out in Fig. 11, where the bulk of an equivalent amount of each kind of diet is exhibited in proper relative proportion.[1]

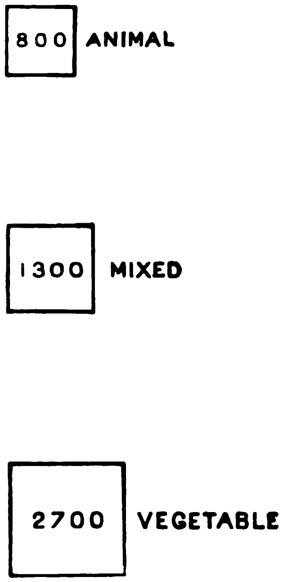

FIG. 11.—RELATIVE BULKS OF AN ANIMAL, A MIXED, AND A VEGETABLE DIET (IN CUBIC CENTIMETRES).

This bulkiness of vegetable food interferes with its digestion in two ways. Firstly, it is difficult for the digestive juices thoroughly to penetrate such a mass, hence the conversion of the nutritive constituents into forms suitable for absorption is apt to be inefficiently carried out; secondly, the large bulk of food stimulates and hastens the movements of the intestine, and the contents of the latter are thus hurried on, and less time allowed for absorption to take place. It is to compensate for this that herbivorous animals have a much onger intestine than the carnivora.

The other great obstacle to the complete digestion and absorption of vegetable foods in the intestine is the presence of **cellulose.** The reasons for this have been already to some extent explained (p. 157). Cellulose is very imperfectly attacked by the digestive apparatus of man and other carnivorous animals. It is only, indeed, while the cellulose is still very young and tender that it is capable of solution to any extent.[2] Under these conditions, an amount varying from 4 up to 60 per cent. or so of the cellulose in the food may disappear in the course of digestion.[3] Whether even this amount is really made use of as food is exceedingly doubtful. Part at least of it seems to be con-

[1] See Voit, *Zeit. f. Biolog.*, Bd. 25, p. 232, 1889.
[2] Meyer, *Zeit. f. Biolog.*, Bd. 7, p. 1, 1871.
[3] Atwater has constructed the following table showing the degree to which cellulose was digested and absorbed in experiments on men:

verted by the action of bacteria into marsh gas and lost to the body.[1]

Cellulose,[2] then, influences digestion and absorption in several ways. It is not only almost useless for purposes of nutrition itself, but prevents the access of the digestive juices to the nutritive ingredients which it encloses, unless it has been thoroughly broken up in the preparation of the food. More than this, being itself unabsorbed, it goes to swell the bulk of the already unwieldy mass

[1] Hoppe Seyler (Schäfer's 'Textbook of Physiology,' i., p. 470).

[2] CELLULOSE DIGESTED IN EXPERIMENTS WITH MEN.

Food used (Quantities per day in Grammes).	Water-free Substance in Food.	Cellulose.		
		In Food.	In Fæces.	Undigested.
	Grms.	*Grms.*	*Grms.*	*Per cent.*
Potatoes, 1,700 grammes; fat, 100 grammes; beer, 500 c.c.; gluten, 200 grammes	—	5·6	1·2	22·0
Potatoes, 1,700 grammes; fat, 100 grammes; beer, 500 c.c.	—	4·8	1·0	21·1
Celery, cabbage, carrots—total, 1,050 grammes	139·0	12·5	4·7	37·3
Celery, cabbage, carrots—total, 883·3 grammes	117·8	10·4	5·5	52·7
Bread, fruit, dry fruit, oil—total, 1,802 grammes	719·0	16·0	9·2	56·0
Bread, fruit, dry fruit, oil—total, 1,764·8 grammes	692·5	16·7	6·3	37·0
Rice and barley, salted radish, vegetables—total, 2,150 grammes	523·8	17·4	4·2	24·0
Rice, salted radish, vegetables, etc., fish —total, 1,800 grammes	615·7	4·6	0·8	17·5
Rice, salted radish, vegetables, etc., meat —total, 1,500 grammes	580·1	6·0	0·5	8·6
Wheat and rye bread (with yeast), 1,000 grammes	616·3	4·3	2·5	63·1
Wheat and rye bread (with yeast), 900 grammes	554·6	3·9	2·0	50·1
Wheat and rye bread (leavened), 1,000 grammes	619·1	4·7	3·3	70·0
Wheat and rye bread (leavened), 900 grammes	557·2	4·3	1·5	36·4
Decorticated (entire) rye bread (with yeast), 1,000 grammes	647·3	8·2	3·7	45·2
Decorticated (entire) rye bread (with yeast), 900 grammes	582·6	7·4	4·1	55·9
Decorticated (entire) wheat bread (with yeast), 1,000 grammes	640·8	6·7	3·7	55·4
Rye bread (with yeast), 1,000 grammes	623·0	8·2	4·9	59·7
Rye bread (with yeast), 900 grammes ..	570·0	7·6	4·8	63·9
Wheat bread (with yeast), 1,000 grammes	640·2	8·9	4·2	47·4
Wheat bread (with yeast), 900 grammes	576·3	8·1	3·8	46·6

which vegetable food forms in the intestine, and takes part in that stimulation of the movements of the bowel which is an additional difficulty in the way of absorption. It is for this reason that foods rich in cellulose, such as brown bread, fruits, and green vegetables, are recognised as useful in the diet of those who suffer from sluggish action of the bowels. Even for healthy persons, a moderate amount of cellulose in the food is a useful intestinal stimulant. Purely carnivorous animals, on the other hand, do not appear to require it at all, whereas for the herbivora, owing to their long and sluggish intestine, its presence in the food is a necessity of life.

This **incompleteness of absorption**, which is the characteristic of most vegetable foods, affects in different degrees their different nutritive constituents. The **fats** appear to be hardly affected by it at all.[1] Cocoa-butter is as well absorbed as ordinary butter, and olive oil as cod-liver oil. **Starch and sugar** also are digested and sucked up into the blood almost to the last particle. It is only when considerable quantities of green vegetables or of such foods as peas and beans are taken that one finds any undigested starch grains in the excreta of healthy persons.[2] It would appear, in fact, that the **proteids** have to bear almost alone the brunt of the defective absorption. Why the proteids of vegetable food should be so much less completely absorbed than the other ingredients, it is somewhat difficult to say; but the results of all experimenters are at one in showing that a relatively larger amount of nitrogen is excreted by the bowel on a vegetable than on an animal diet.

RELATIVE ABSORPTION OF PROTEID IN VARIOUS FOODS.

Diet.	*Proteid not Absorbed.*
Meat[3]	2·3 per cent.
Lentil flour (218 grammes daily)[4]	10·5 ,,
Dried peas (600 ,, ,,)[5]	17·0 ,,
Beans (500 grammes) Flour (17 ,,)[6]	30·3 ,,
Potatoes (3,000 grammes)[7]	32·0 ,,
Carrots and fat (412 grammes, dried)[8]	39·0 ,,
Lentils (250 grammes, simply soaked and boiled till soft)[9]	40·0 ,,

[1] See experiments by Bourot and Jean and by Blumenfeld (*Jahres-Ber. über Thier. Chem.*, 1896, p. 58, and 1895, p. 46), also Bendix (*Therap. Monatshefte*, 1895, p. 345)
[2] See Moeller, *Zeit. f. Biolog.*, Bd. 35, p. 91, 1897.
[3] Rubner, *Zeit. f. Biolog.*, pp. 121, 125, 1879.
[4] Strümpell, *Deut. Archiv. f. Klin. Med.*, Bd. 17, p. 108, 1876.
[5] Rubner, *Zeit. f. Biolog.*, pp. 127, 28, 1880.
[6] Prausnitz, *Ibid.*, p. 227, 1890.
[7] Rubner, *Ibid.*, pp. 147, 166, 1879.
[8] *Ibid.*
[9] *Loc. cit.* (2).

In the table a number of such experiments, which were all carried out on healthy persons, have been collected, and the percentage of proteid which escaped absorption in each food compared with that in meat. It will be observed that all the vegetable foods exhibit a much greater loss of proteid than meat does.

In a number of prison diets of an exclusively vegetable nature, in which the proteid ranged from 106 to 56 grammes, or, if bread were excluded from the reckoning, from 41 to 2 grammes daily, it was found[1] that on an average from 25 to 47 per cent. escaped absorption. Schuster also observed,[2] in Houses of Correction where bread, pulses, potatoes, and green vegetables were given, and only 60 grammes of meat three times in the week, that, of the 104 grammes of proteid supplied, only 78 grammes (72 per cent.) were absorbed, but that in prisons where 116 grammes of meat and only three-fifths as much vegetables were supplied, 87 per cent. was absorbed.

It would appear that the mere presence of a large amount of starch in the intestine is *per se* unfavourable to the absorption of proteid.[3] This is probably to be attributed to the fermentation of part of the starch, and the production of acids which unduly quicken the intestinal movements; on the other hand, a moderate degree of such acid production ought to be actually favourable to the absorption of proteid, by restraining the growth of putrefactive germs in the intestine, which would speedily break up the proteids of the food and carry them past the stage in which they are available as foods. Doubtless, also, the effects of cooking are less favourable to the digestion of proteid than to that of starch. Under the influence of heat and moisture, the starch grains swell and rupture and burst through the walls of cellulose which enclose them, but under similar circumstances the proteid in the vegetable cells is coagulated and shrinks away from its wall of cellulose, so that the latter is likely to remain unruptured. There are some[4] who go so far as to say that the large amount of nitrogen found in the intestinal excreta on a vegetable diet is not derived from unabsorbed proteid, but from the residue of the digestive juices. On this view of the facts the vegetable foods must require a larger amount of the digestive juices for their solution than the animal foods do. Even if we accept this explanation as in part, at least, correct, the fact remains that

[1] Hofman, 'Die Bedeutung von Fleischnahrung,' Leipzig, 1880.
[2] Quoted by Munk, Weyl's 'Handbuch der Hygiene,' iii. 116.
[3] Wicke and Weiske, *Zeit. f. Physiolog. Chemie*, xxi. 42 and xxii. 137, 1896.
[4] See Prausnitz, *Zeit. f. Biolog.*, Bd. 35, 1897, p. 287.

relatively more nitrogen is lost from the bowel on vegetable than on animal food, and from this, as we shall see shortly, various practical consequences can be deduced.

3. The Nutritive Value of Vegetable Foods.

If we consider the chemical constituents of vegetable foods—the proteids, carbohydrates, and fats—by themselves, we may safely conclude that they are equal in nutritive value to the corresponding substances derived from the animal kingdom. It is true that it has been suggested[1] that the smaller proportion of carbon in **vegetable proteid** renders it inferior in nutritive value to proteids of animal nature; but of this no satisfactory proof has been advanced, and against it is the fact that, of the two, it is vegetable proteid which yields the greater amount of heat on combustion. The experience of vegetarian races would also tend to negative such a view. Not only so: exact experiments, which were carried out by a German observer[2] over a period of some weeks, have shown that if the proteid contained in the meat and milk of an animal diet is replaced by a similar quantity of proteid in the form of peas and beans, the nitrogen balance of the body suffers no impairment.

As regards the carbohydrates nothing need be said. **Starch and sugar** are of necessity derived almost entirely from vegetable sources, and their high nutritive value is beyond dispute.

As regards **fat** also, the daily experience of the Southern European countries is confirmed by scientific experiments, which show that vegetable fats, such as olive oil and cocoa-butter, are as valuable as means of nourishment as the fats of meat or milk.[3]

But we must by no means suppose, merely because the chemical constituents of vegetable food are equal in nutritive value to the corresponding constituents of animal food, that therefore vegetable food as a whole can replace meat, and *vice versâ*. The form in which the nutritive ingredients are presented to the digestive organs materially affects their utility as foods. A glass of whisky is chemically the same whether it be taken 'neat' or diluted with a tumblerful of water, but the effects on the body are radically different.

The question, therefore, presents itself: Is it better to obtain the nutritive constituents of our food in an animal or a vegetable form? and an attempt to reply to this question raises the whole problem of

[1] Chittenden, *Medical News*, Philadelphia, lviii. 716, 1891
[2] Rutgers, *Zeit. f. Biolog.*, Bd. 24, p. 351, 1888.
[3] See references in footnote, p. 164.

vegetarianism. With that problem we must now concern ourselves for a short space.

The 'vegetarians,' using the term in its generally accepted, though somewhat inaccurate, sense, are, as is well known, persons who seek to abolish the use of flesh as an article of human diet. This doctrine may be defended on three grounds :[1]

1. Physiological: That the practice of vegetarianism is conducive to a healthier and longer life, and to a better moral temperament than the use of a mixed diet.

2. Economical: That it is less costly both to the State and to the individual.

3. Moral: That the slaughter of animals for food is unjustifiable on grounds of humanity.

It is obvious that each of these arguments will appeal with different force to different readers, but it is only with the first two that we can deal at any length here.

As regards the **physiological argument**, it may be pointed out—what is apt to be lost sight of—that the vegetarian question is really a question of nitrogen, and of that alone. The carbohydrates of the diet must almost perforce be derived from the vegetable kingdom, for there alone are they to be found in any quantity, and it has already been pointed out that the fat of the diet may be obtained with equal physiological advantage from either an animal or a vegetable source.

But as regards proteids it is different. Granted that a given quantity of pure vegetable proteid is fully equal in nutritive value to a similar quantity of the proteid of flesh, we are still unable to extract the vegetable proteid in a state of purity and eat it by itself, but must take it in the form in which it is presented to us by Nature. The real question, therefore, is: Shall we eat our proteid in an animal or a vegetable form? Now, in the first place, it will scarcely be denied that vegetable foods are relatively much poorer in proteid than animal foods are. Contrast typical examples of both kingdoms after the removal of water, for that is the only fair method of comparison, and one arrives at the following results:

100 parts of dried lean beef contain ..	..	89 parts of proteid.
,, ,, fat beef contain ..	.. ..	51 ,, ,,
,, ,, pea flour ,, ..	.. ..	27 ,, ,,
,, ,, wheat ,, ..	.. ..	16 ,, ,,
,, ,, rice ,, ..	.. ..	7 ,, ,,

[1] F. W. Newman, "Essays on Diet," p. 64.

The comparison shows that even the fattest meat is far richer in proteid than the most nitrogenous forms of vegetable food.

Not only so: what proteid is present in vegetable food has its value still further lowered in many cases by the defective nature of its absorption in the body. The truth of this has been already sufficiently demonstrated.

It must be obvious from all this that vegetable food, unless eaten in large quantities, will not yield a sufficiency of proteid to the body. The important question arises, therefore: How much proteid does a healthy man require in his food daily? This question has been discussed in an earlier chapter, and it is only necessary to remind the reader that the amount of proteid which is required daily by a healthy man doing a moderate amount of bodily work has been variously estimated at something from 100 to 130 grammes. And what are the consequences of living upon a diet which contains less proteid than this? To this question, as we have also seen (p. 23), it is not easy to give an altogether satisfactory reply. In the first place it must be admitted that such a large amount of proteid is by no means necessary for making good the mere daily waste of proteid in the body. Very much less will suffice for *that*, and carefully-conducted experiments have shown that no impairment of the stock of proteid in the body is incurred even if the amount in the food be cut down to as low a level as 75 grammes daily. Even if it be objected to such experiments that this minimum consumption of proteid has only been maintained for very limited periods, yet I think one may reply with truth that the minimum reached is not much below that which forms the average daily consumption per individual in a large number of healthy races, such, for example, as the Japanese.[1] The reply of scientific experiment, therefore, as far as it can be applied to the problem under consideration, would be that it is undoubtedly possible to maintain a healthy life upon such a daily amount of proteid as is contained in a moderate quantity of vegetable food, and the accumulated experience of vegetarian races fully bears this out.

This, however, does not dispose of the question. There is such a thing as **degrees of health**. While one freely admits that health and a large measure of muscular strength may be maintained upon a minimum daily supply of proteid, yet I think that a dispassionate survey of mankind will show that races which adopt such a diet are lacking in what, for want of a better word, one can only describe as *energy*. Now, **energy** is not to be confused with muscular strength.

[1] It may be fairly objected to this statement that the average individual in such races is of much smaller body-weight than the ordinary European.

A grass-fed cart-horse is strong; a corn-fed hunter is energetic. Energy is a property of the nervous system; strength, of the muscles. Muscles give us the power to do work; the nervous system gives us the initiative to start it. Muscles do their work upon carbohydrates, which are the characteristic nutritive constituent of vegetable foods; the brain appears to require nitrogen, which can only be obtained in a concentrated form from animal sources. If proteid food, therefore, be regarded as a nervous food, a diet rich in it will make for intellectual capacity and bodily energy, and it is not without reason that the more energetic races of the world have been meat-eaters.

The Scotch peasants are often adduced as an example of a high degree of energy and intellectual capacity produced from a vegetable diet. But this is the very exception which proves the rule, for the Scotch peasant of the last generation was not only fed on a highly nitrogenous form of vegetable food—oatmeal—but the proteid of this was still further supplemented by the addition of milk, of which 2 to 3 Scotch pints (each equal to $3\frac{1}{8}$ imperial pints) used to be allowed to each family daily in the form of wages.[1]

The difference, in fact, between an animal fed on a highly nitrogenous diet and one supplied with little nitrogen is the difference between a steam-engine at half-pressure and one which is producing its full horse-power. It is the difference between a tiger pacing its cage and a cow lying upon the grass; both are healthy, but the type or degree of health is very different in the two cases.

'The hunted deer,' says Haughton, 'will outrun the leopard in a fair and open chase, because the work supplied to its muscles by the vegetable food is capable of being given out continuously for a long period of time; but in a sudden rush at a near distance, the leopard will infallibly overtake the deer, because its flesh food stores up in the blood a reserve of force capable of being given out instantaneously in the form of exceedingly rapid muscular action.'

Not only, I think, does a diet rich in proteid make for physical and mental energy: it seems to increase also one's **power of resisting disease** (see also p. 175).

An abundant supply of proteid seems to be necessary if the blood and muscles are to be kept in good condition, and by promoting oxidation it increases vigour and diminishes the tendency to an undue accumulation of fat. The nervous system, too, seems to require a plentiful supply of proteid if those mysterious influences which emanate from the brain and spinal marrow are to be

[1] See papers by R. Hutchison, F.R.S.E., already quoted (p. 33).

maintained with sufficient potency to enable the tissues to ward off the inroads of disease.

To growing children a deficiency of proteid in the diet is specially disastrous, for the lack of building material which it entails may result in impaired growth and development, the consequences of which may last throughout life.

For the same reason persons who habitually live on a minimum of proteid are apt to convalesce but slowly after an acute illness, for once their tissues are broken down, they have no ready surplus of building material out of which to repair them.

Everyone knows the feeling of well-being which follows a meal containing meat. That this is due to the proteid in meat, and not to its extractives, is shown by the fact that whereas the addition of the extractives of meat to foods, such as bread, is unable to produce this feeling, yet such vegetable substances as oatmeal, which are rich in proteid, are capable of exciting it in a considerable degree. A full meal of nitrogenous food is an actual stimulant to the tissues of the body, and is of value even if it only comes at long intervals, for its good effects would appear to be not altogether of a transient nature. This stimulation of the tissues must also make for resisting power.

Of course, there is another side to all this, and the consumption of an excess of nitrogenous food is not free from dangers (see p. 53). At the present time there is no great likelihood that the English-speaking races, at least, will suffer from a deficiency of nitrogen in their food. The danger, indeed, is all the other way, in the direction of a too liberal consumption of meat. It is for insisting upon the disadvantages of such a course, and on the feasibility of living upon a diet from which meat is altogether excluded, that we in this country owe even the extremest vegetarians a considerable debt of gratitude.

Granted, then, that the consumption of only a moderate quantity of purely vegetable food is apt to mean a lack of proteid in the diet, with all its attendant risks, we have next to ask, How may this deficiency be supplemented? The reply is that this may be effected in one of three ways:

1. The **mixed feeder** solves the problem by adding to a considerable basis of vegetable material a moderate amount of food obtained from animal sources. Meat and fish are concentrated forms of proteid food, and by their use he is able to supplement the comparatively small amount of nitrogen contained in the rest of his diet.

What the ideal **proportion between the vegetable and animal**

constituents of a mixed diet should be it is a little difficult to say. Voit considers that 35 per cent. of the total proteid required daily should be taken in an animal form. This would be represented in an ordinary diet by 7 ounces of meat (two moderate-sized platefuls). If the proportion of animal proteid is habitually three-fourths of the total, it is considered by many that there is a danger of producing disease, especially gout.

Actual observation of eighty-seven dietaries in the United States showed that, of the total food consumed, 45 per cent. was in an animal, and 55 per cent. in a vegetable, form. The former proportion is probably too high, and in all likelihood we shall not be far wrong if we reckon that an ordinary diet should contain one part of raw animal food to every three parts of uncooked vegetable material. This relation is pretty nearly observed in the relative proportions of meat and bread in an ordinary sandwich. It is obvious, however, that the exact proportions must vary somewhat with the form in which the vegetable food is taken.

2. There is a special class of 'vegetarians' who supplement the proteid of their diet from two animal sources only—**eggs and milk.**[1] That these are both well adapted to supply proteid we have already seen, but their superiority to meat and fish is not so evident. A diet of this sort has been investigated by Cramer.[2] It consisted of whole-meal bread, potatoes and fruit, with the addition of eggs and milk. The consumer was a so-called vegetarian of eleven years' standing. The diet contained altogether only 74 grammes of proteid, of which rather more than one-third was derived from the eggs and milk. It was therefore deficient in proteid to start with, and not only so, but fully 21 per cent. of the proteid was found not to be absorbed.

A more liberal use of milk might have remedied the defects in this diet, and it would then be open to no physiological objection, except the difficulty (and often the expense) of obtaining a sufficient supply of milk. The addition of cheese would also be an advantage.

There is no doubt that this modified form of vegetarianism has much to recommend it, and it often agrees better with gouty persons than a diet into which meat enters in any amount.[3]

3. To the **consistent vegetarian** the only available method of increasing the proportion of proteid in his diet is by increasing the

[1] This is sometimes called the 'V. E. M.' diet, from its consisting of vegetables, eggs and milk. The term was first introduced by the late Professor Jarrett, of Cambridge (see Newman's 'Essays on Diet').

[2] *Zeit. f. Physiolog. Chemie*, vi. 346, 1882.

[3] See Haig's 'Diet and Food,' London, 1898. Haig also discourages the use of eggs.

total amount of food consumed, and especially by having large recourse to those vegetable substances, such as the pulses, which are specially rich in nitrogen.

Let us suppose that dry lentils are selected as the proteid-carrier. It would take 450 grammes of these to supply the total proteid required daily, and this quantity must be further increased to

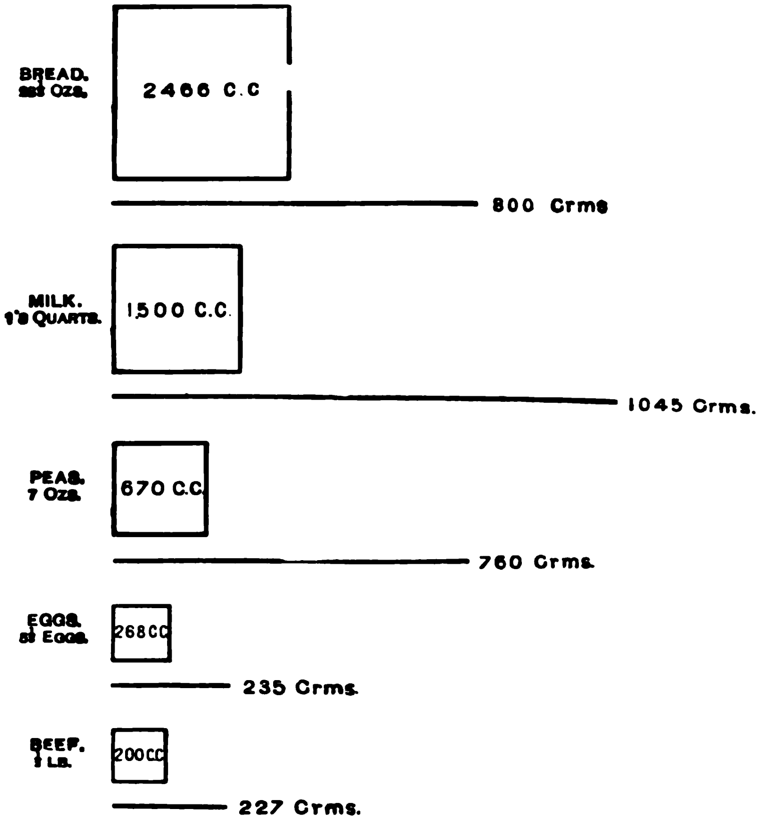

FIG. 12.—BULK AND WEIGHT OF DIFFERENT FORMS OF FOOD YIELDING THE SAME QUANTITY OF PROTEID.

500 grammes in order to allow for the loss of 10 per cent. of proteid from defective absorption, and when cooked into a thick porridge the total weight of the mass would be 2,000 grammes. Now, this is a very formidable figure when one remembers that only 600 grammes of cooked meat would be required to supply the same amount of proteid.

In the preceding diagram (Fig. 12) the bulk and weight of different

forms of cooked animal and vegetable food required to yield the same amount of proteid are contrasted, and they conclusively demonstrate the superiority of eggs and meat as compact sources of nitrogen even over milk, and still more over such vegetable foods as bread and peas.

The conclusion, therefore, seems justified even on *a priori* grounds, that, if one attempts to obtain a due supply of proteid in a purely vegetable form, he must be prepared to consume a rather bulky diet. Actual observation confirms this. Even the above-mentioned 'vegetarian' consumed about 2,960 grammes of cooked food daily. If he had replaced the eggs and milk in his diet by vegetable foods, the total quantity would have risen to nearly 3,500 grammes. Seeing that the total capacity of an ordinary stomach is only about 1,200 grammes,[1] this means that the stomach must be filled to the limit of its capacity thrice in the day. And yet even then we saw that only 74 grammes of proteid would be ingested.

The causes of this **inevitable bulkiness** of a purely vegetable diet have already been dwelt upon and have been shown to depend on the wateriness of vegetable food, especially when cooked, and on the large amount of indigestible cellulose which it contains, to which may be added that the small amount of proteid present is diluted, as it were, by a disproportionate quantity of starch. Hence, in order to get a sufficiency of proteid in a purely vegetable diet, one is obliged to consume much more starch than is really required. The **physiological effects of this excessive bulk** now call for some consideration.

One of the first results of the habitual ingestion of a bulky diet is that the **stomach and bowels become somewhat distended**. Examples of this are found in the disproportionate abdominal development of cattle and other herbivora, and in the so-called 'potato-belly' of the Irish peasant. This distension has the effect of increasing the capacity of the stomach so that more food can be taken. Indeed, until this increase in capacity has taken place there is difficulty in consuming a sufficiency of purely vegetable food to meet the demands of the body. For this reason the adoption of a vegetable diet is useful in some forms of obesity, especially when complicated by habitual constipation. The treatment involves a species of fraud upon the body, the distension of the stomach producing a feeling of satiety before a sufficiency of nutriment has really been taken in. Unfortunately, the increase in capacity of the abdominal organs, by which the greater bulk of a vegetable diet is compensated for, does

[1] See Hofman, 'Die Bedeutung von Fleischnahrung.'

not seem to be accompanied by an increased power of digestion and absorption. Observations made upon vegetarians of several years' standing by Voit[1] and by Cramer[2] showed that the amount of food which escaped digestion in these subjects was quite as great as one finds it to be in those who have but recently adopted that form of diet. Indeed, one of the results most commonly observed to follow the habitual use of purely vegetable food is an enfeeblement of the digestive organs and a tendency to chronic diarrhœa. The reason for this is, perhaps, that the very bulkiness of vegetable food, and its tendency to undergo acid fermentation, causes it to be hurried through the small intestine into the larger bowel, where absorption is much less active. Thus, one finds that whereas the average amount of material evacuated daily from the large bowel on an animal diet amounts to 120 grammes, it reaches 333 grammes in the case of a purely vegetable feeder.[3]

The very necessity for the manipulation by the stomach and bowels of such a large mass of material constitutes another of the disadvantages of a purely vegetable diet. For such manipulation involves greater muscular effort on the part of the stomach and intestinal walls, and that implies **a large expenditure of blood and of nervous energy**. There is thus less of these left for other purposes, and especially for the use of the brain, hence the feeling of lassitude always experienced after a heavy meal. This prostitution of nervous energy, from higher purposes to the mere manipulation of food which vegetarianism involves, is another reason for regarding that mode of life as a retrogression in civilization. The more concentrated (within reasonable limits) we can manage to make our food, the more easily is it appropriated by the body, and the greater is the amount of energy which we have to spare for our intellectual and other needs.

It must be added, lastly, that the **wateriness**, which is such a pronounced characteristic of vegetable food, is itself a disadvantage. Observation even shows[4] that it does not, as is often maintained, diminish the amount of water which is drunk. On the other hand, the fluid in the food is absorbed into the blood and retained in the body, rendering its fluids more dilute and its tissues more watery. It is probable that this accounts for the 'soft' condition and flabbiness of those who habitually consume large quantities of the more watery forms of vegetable food. It is doubtless also an

[1] Voit, *Zeit. f. Biolog.*, Bd. 25, p. 232, 1889.
[2] Cramer, *Zeit. f. Physiolog. Chemie*, vi. 346, 1882.
[3] Voit, *Zeit. f. Biolog.*, Bd. 25, p. 232, 1889.
[4] See Meyer, *Zeit. f. Biolog.*, Bd. 7, p. 1, 1871, and Rutgers, *ibid.*, Bd. 24, p. 351, 1888.

important factor in producing the low resisting power which is characteristic of such persons. That this low resistance to disease, to which reference has so often been made, is no mere bogey of the scientific imagination is shown by the history of the epidemics which from time to time break out amongst those who are compulsorily maintained on an entirely vegetable diet. One good example of such an epidemic is related by Hofman.[1] The prisoners in the German prison at Waltenburg were fed on a diet of rye-bread, 'groats,' and pulses. In the year 1854 an epidemic, resembling scurvy in its symptoms, and attended by great prostration, broke out amongst them. Under the belief that the disease was due to a deficiency of nitrogen in the food, the proportion of peas and beans in the diet was increased. Notwithstanding this the ravages of the malady extended. Immediately, however, upon the substitution of milk and meat for the pulses the disease ceased to spread, and those already affected made a rapid recovery.

The same feebleness of resistance is noticeable in individual examples of vegetarianism. Thus the vegetarian to whom reference has already been made as subsisting upon 74 grammes of proteid daily (p. 171), is related to have been subject to attacks of bronchitis and gastric catarrh upon very slight provocation, and when so attacked to have passed very rapidly into an alarming state of prostration.

In concluding this subject, it should be pointed out that the **disadvantages of a purely vegetable diet** affect the outdoor labourer much less than one engaged in more sedentary pursuits. The labourer actually requires a large amount of carbohydrate to enable him to perform his muscular work, and in eating large quantities of vegetable food for this purpose he is almost sure to get as much proteid as he requires also. The free action of the skin, too, which his work insures carries off from the body the excess of water which his diet contains.

With the sedentary worker, however, the case is different. He requires much less carbohydrate than the labourer, while his demand for proteid still remains considerable; and in endeavouring to obtain from purely vegetable sources a sufficiency of the latter ingredient he inevitably overburdens his diet with an excess of the former, while he has no ready means of getting rid of the surplus water which it contains. For this reason the sedentary man is much less likely to be a successful example of vegetarianism than one who leads a more active life. General experience, I think, bears this out.

[1] Hofman, 'Die Bedeutung von Fleischnahrung,' Leipzig, 1880.

4. Relative Economy of Vegetable Food.

When the relative cost of animal and vegetable food comes to be considered, the vegetarian is on much firmer ground. There can be no doubt that **vegetable food is much the cheapest**. This is shown in the diagram to which attention has already been directed (Plate III.), and which exhibits the number of Calories obtained from a shilling's worth of different forms of food. One sees that a given sum yields a far larger amount of fuel for the body when spent on bread, peas, or potatoes, than when invested in eggs, fish, or beef, or even in such comparatively cheap animal foods as cheese and milk.

This superiority of vegetable food applies not merely to the carbohydrates and fats, which are its fuel constituents, but to proteids as well. The following table shows the **cost of 1 pound of proteid** when purchased in different forms :

1 pound proteid in peas costs	7d.
" " oatmeal costs	7½d.
" " bread "	1s. 6d.
" " milk "	2s. 2d.
" " beef "	2s. 8d.

On an average, therefore, one will get about four times as much vegetable as animal proteid for a given sum.

A consideration of the respective methods by which plants and animals derive the raw material for building up their tissues will prove that the former must *necessarily* be cheaper sources of food-supply than the latter.

The atmosphere and the soil are the primary sources of all food. The former contains carbon in the form of carbonic acid gas along with water vapour. The latter contains water and nitrogen in the form of nitrates. Now, animals are unable to make use of carbon and nitrogen in these simple forms, but plants can. The plant, aided by the light and heat of the sun, and by water, builds up the carbon of the carbonic acid gas into carbohydrates. These are eaten by animals, and broken up by them into carbonic acid gas and water, and returned through the lungs in that form to the atmosphere once again (see Fig. 13). The plant also lays hold of the nitrates in the soil, and works up the nitrogen which they contain along with some of the carbon derived from the atmosphere into complex vegetable proteids (Fig. 14). These also are consumed by animals, and after a brief life as the proteids of muscle and other tissues, are eliminated through the kidneys in the form of urea. By the action of bacteria,

the urea is further broken up into compounds of ammonia, and these in their turn are taken in hand by another set of bacteria, and the nitrogen which they contain converted into nitrates once more.

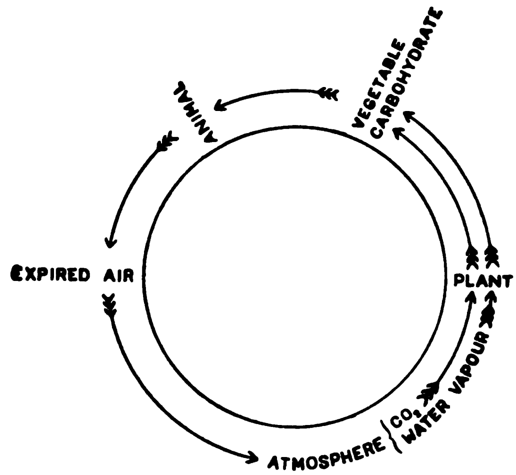

FIG. 13.—CARBON FOOD CYCLE.

Not all of the nitrogen, however, is so fortunate. Part of it is split off, and goes to join the immense mass of free nitrogen contained

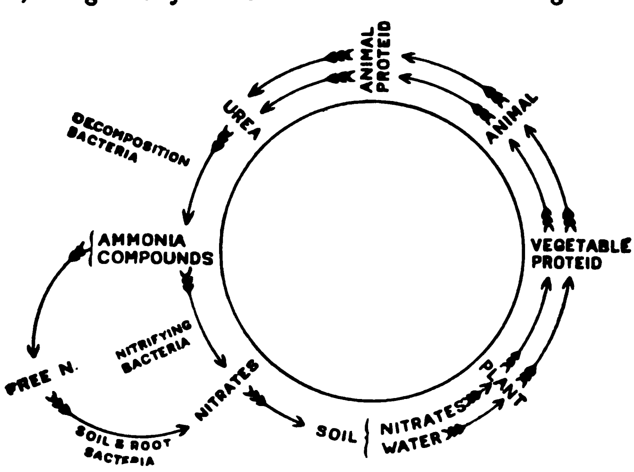

FIG. 14.—NITROGEN FOOD CYCLE.

in the atmosphere. There is, then, a certain loss of nitrates from the soil when the latter produces vegetables which are used for animal food. The loss would be greater than it actually is were it not for

the existence of another kind of bacteria, whose acquaintance scientific men have but recently made. These establish themselves upon the roots of certain plants, especially the pulses, and perform the kindly office of laying hold of some of the free nitrogen in the air and fettering it in the form of nitrates. Thus they enrich the soil and feed the plant on whose roots they live. In this way the nitrogen food-cycle of the world is completed.[1]

It is owing to this constant loss on the part of the soil that farmers are in the habit of using nitrates as a manure for fields from which heavy crops of cereals are continually being taken. In a recent address by Professor Crookes before the British Association, it will be remembered how he pointed out that the available supply of nitrates is running short, and predicted that dire results would follow upon its complete exhaustion.

One may now naturally ask: Would it not be possible for science to step in, and itself work up the primitive forms of food into those complex forms which animals require, without the aid of plants? In the case of carbohydrates this has already been achieved, for sugar can be built up out of its elements by the chemist as well as by the plant. It is in the case of the proteids, however, which are such expensive forms of food, that an artificial method is most to be desired. But even with respect to them recent research is stated to have been crowned with success, and a form of proteid produced which is identical with the same article as manufactured by Nature. It is not likely, however, that these chemical processes can be carried out on a commercial scale. Certainly not for a very long time to come. And yet, were it possible to fix directly the free nitrogen which is waiting in unlimited quantity in the atmosphere, the problem would be half-way to solution. In the address to which reference has been made, Professor Crookes indicated a method which gives reason to hope that this may yet be done, and the nitrogen of the air be converted into nitrates in the same way as by the action of root bacteria. Though such compounds are of no direct use as food to man, yet they could be used to prepare the soil for abundant crops of grain. Notwithstanding all these scientific conquests, accomplished or imminent, those who do not look forward to the day when foods will be swallowed in the form of compressed tablets need not be filled with despair. It by no means follows because an artificial product is identical with a natural one in composition that

[1] The reader will find a much fuller account of Nature's food-cycle, and the part played in it by bacteria, in 'The Story of Germ Life,' by H. W. Conn (London: George Newnes, Lim.), chap. iv.

therefore it can replace the latter as a food. The analyst may pronounce two compounds the same, but the living body can often detect subtle differences which may lead it to make use of the one and reject the other. That, at least, has been the experience with such scientific preparations as 'artificial milk.

The differences in the mode of feeding of animals and plants respectively, which have been above described, are well summed up in the saying of an eminent French physiologist, that in the main animals are *analytical*, and plants are *synthetical*, feeders. And seeing that this is the case, seeing that animals must have complex compounds as their nutriment, and that these can only be derived either from vegetables or from the flesh of other animals, it follows that the former must be a much cheaper source of supply than the latter. The difference is exactly the same as between dealing with a manufacturer direct and through the medium of a middle-man. In converting vegetable compounds into flesh an animal takes toll of them. It has its commission, which must be paid by the individual who consumes the flesh and by the community. That the commission amounts to a considerable percentage of the original vegetable food is not open to dispute. 'It is not extravagant to say,' writes one author, 'that every acre well cultivated would feed seven times as many men by its crops as could be fed on the flesh of cattle who do but graze on its spontaneous grasses;'[1] and the same writer asserts that it has been found in a vast pig butchery at Cincinnati that the oatmeal used in fattening the pigs would have gone nearly four times as far as the pork produced went in feeding mankind.[2] Another investigator has calculated that 2½ acres devoted to the production of mutton will support one man a year, whilst the wheat grown on the same area would support sixteen men.[3] Without committing ourselves to the literal correctness of such calculations, we may yet believe that they are a close approximation to the truth, and the economic questions which they suggest are of far-reaching national importance. But however this may be from the point of view of a nation as a whole, individuals in civilized countries are always found to be willing, when they are able, to pay for animal food the high price demanded for it, by reason of the imperious necessity of obtaining a concentrated form of nitrogenous food. From the individual point of view, too, it must be remembered that there is an offset to the comparative cheapness of vegetable food in the larger

[1] Newman, 'Essays on Diet,' p. 4. [2] *Ibid.*, p. 5.
[3] Hunter, 'Dietetic Reformer.'

amount of cooking which such a diet entails. One scientific writer,[1] who inquired into this point in his own case, found that a mixed diet cost him 2s. 7½d. per diem, while a purely vegetable diet cost 2s. 3d.; but the former required only eighteen and a half hours' cooking in the week, the latter sixty-three hours. Assuming that the fuel cost ½d. per hour, this would mean that the cost of the mixed diet, plus cooking, was 19s. 1½d. per week, as compared with 18s. 4d. for the vegetable diet—a difference which is very slight. If these figures be at all correct, it is not true to say, as some have done, that the abandonment of meat is equivalent for a working man to a rise of 5s. a week in his wages.

In conclusion it may be well to summarize the main points in the argument which has been pursued in this chapter:

1. Vegetable foods are rich in carbohydrates, and, with a few exceptions, comparatively poor in proteid and fat. They are also bulky, partly from their richness in starch, but also from the presence of cellulose and a large amount of water. Even if compact in their raw state, they tend to take up much water and to become bulky on cooking.

2. Animal foods are rich in proteid and fat, but, with the exception of milk, poor in carbohydrates. They are compact in form (again with the exception of milk), and tend to become more so on cooking.

3. Vegetable foods tend to be less digestible in the stomach, and on the whole less completely absorbed than animal foods, partly by reason of their bulk, partly because of the indigestible coating of cellulose which invests their nutritive constituents, and in part also from their tendency to undergo fermentation in the intestine, with the production of acids which hasten on peristalsis. Their proteid constituents suffer more from defective absorption than any other ingredient.

4. Both from chemical composition and from defective absorption a purely vegetable diet is apt to be deficient in proteid, and the question of vegetarianism becomes a question of nitrogen.

5. The consistent vegetarian is thus placed in a dilemma. He has either to live on a diet deficient in proteid or to consume an excessive bulk of food.

6. The adoption of the former of these courses tends to diminish energy and the power of resisting disease; the latter is apt to lead to derangement of the stomach and bowels.

7. Both of these results may be avoided by supplementing the vegetable part of the diet by animal substances rich in proteid, but

[1] Rutgers, *Zeit. f. Biolog.*, Bd. 24, p. 351, 1888.

two-thirds of the total proteid can safely be taken in the vegetable form.

8. Either meat, fish, eggs, milk or cheese may be used as the proteid-carrier, but for healthy persons the moderate use of the first two has certain advantages. For the gouty, perhaps milk and cheese are more to be recommended, while skim or butter milk, salt fish, and the cheaper kinds of cheese are undoubtedly the most economical.

9. Vegetable foods have certainly the advantage of being cheaper, both as sources of building material and energy, than the animal foods are, and vegetarianism may therefore be recommended on grounds of economy, both national and individual. The reasons for the inevitable costliness of foods of animal origin have been pointed out; the cost of cooking, however, must not be lost sight of in this connection, and modifies somewhat the above considerations.

10. It may finally be added, though these points were not dwelt upon, that vegetable foods are less highly flavoured than some animal foods, such as meat, but have the advantage of not being liable to undergo putrefaction, and of rarely producing disease.

CHAPTER XI

THE CEREALS: WHEAT—BREAD

In the present chapter we begin the study of the vegetable foods in detail. In classifying these, it is better to be guided by practical convenience rather than by strict botanical considerations, and we may accordingly group them under the following heads:

1. The cereals, *e.g.*, wheat, oats, maize, etc.
2. The pulses, *e.g.*, peas, beans, lentils, etc.
3. The roots and tubers, *e.g.*, carrots, turnips, potatoes, etc.
4. Green vegetables, *e.g.*, the cabbage.
5. Fruits and nuts, *e.g.*, the apple and walnut.
6. Fungi and algæ, *e.g.*, mushrooms and Irish and Iceland moss.

In a separate chapter we shall devote some special attention to the different forms in which sugar and spices enter into the diet.

The Cereals.

From the botanist's point of view, the cereals belong to the tribe of grasses. The only part of them made use of as human food is the fruit or seed. In all grasses there is laid up in the seed a storehouse of nourishment for the young plant during the early days of its career. It is interesting to note that the effect of cultivation is to encourage the 'foresight' of the parent plant in providing for its young, so that in the cultivated grasses (*i.e.*, the cereals) this storehouse becomes very considerable, and in robbing the young plant of it we tap an abundant source of food-supply. In all of them the different nutritive ingredients—proteids, carbohydrates, fat, and mineral matter—are represented, along with a certain proportion of water, which, however, in the ripe seed does not amount to more than 10 to 12 per cent. of the whole grain.

The **proteids** vary considerably in kind in the different cereals, but their nutritive value is probably about equal. They average,

like the water, about 10 to 12 per cent. In addition to the proteids, small quantities of other nitrogenous substances (*e.g.*, amides) are present, the amount of which varies in different cereals. They are always more abundant in the growing plant than in the mature condition.

The chief **carbohydrate** present is starch. This makes up from 65 to 70 per cent. of the entire grain. Small quantities of sugar are also met with, but cellulose is not abundant except in the outer protective covering. This fact is of considerable advantage as far as the digestibility of the cereals is concerned.

The proportion of **fat** varies very notably in different members of the group. It is interesting to note that it tends to be most abundant in those cereals which grow in northerly latitudes, *e.g.*, oats, whereas in the cereals of tropical growth, *e.g.*, rice, it is almost absent. In this the cereals seem to follow a general law, for just as the young whale is provided by Nature with a milk specially rich in fat, so the young cereal which has to grow up in a cold atmosphere is supplied with an abundant store of oil.

The **mineral matter** amounts to about 2 per cent. of the grain, lime and phosphoric acid being most abundantly represented, while the organic salts are almost absent. In this respect the cereals resemble the animal rather than the vegetable foods.

Summing up this rapid review, the **general composition of the cereals** may be said to be something as follows:

Water	10 to 12 per cent.
Proteids	10 ,, 12 ,,
Carbohydrates	65 ,, 75 ,,
Fat	½ ,, 8 ,,
Mineral matter	.. 2 ,,

COMPOSITION OF CEREALS.[1]

	Water.	Proteid.	Fat.	Carbo-hydrates.	Cellu-lose.	Mineral Matter.
Wheat	12·0	11·0	1·7	71·2	2·2	1·9
Oats	10·0	10·9	4·5	59·1	12·0	3·5
,, (hulled)	6·9	13·0	8·1	68·6	1·3	2·1
Barley	12·3	10·1	1·9	69·5	3·8	2·4
Rye	11·0	10·2	2·3	72·3	2·1	2·1
Maize	12·5	9·7	5·4	68·9	2·0	1·5
Rice (in the husk = 'paddy')	10·5	6·8	1·6	68·1	9·0	4·0
Rice (husk removed) ..	12·0	7·2	2·0	76·8	1·0	1·0
,, (polished)	12·4	6·9	0·4	79·4	0·4	0·5
Millet	12·3	10·4	3·9	68·3	2·9	2·2
Buckwheat	13·0	10·2	2·2	61·3	11·1	2·2

[1] The table represents the composition of the cereals in their crude form The figures are compiled from a vast number of analyses, the data contained in the

COMPOSITION OF PRODUCTS DERIVED FROM CEREALS.

	Water.	Proteid.	Fat.	Carbohydrates.	Cellulose.	Mineral Matter.
Wheat meal	12·1	12·9	1·9	70·3	1·6	1·2
Fine wheat flour ..	13·0	9·5	0·8	75·3	0·7	0·7
Oatmeal	7·2	14·2	7·3	65·9	3·5	1·9
Rolled oats	7·2	15·4	7·2	64·8	3·5	1·9
Barley meal	11·9	10·0	2·2	71·5	1·8	2·6
Pearl barley	12·7	7·4	1·2	76·7	0·8	1·2
Coarse rye flour ..	11·4	15·3	2·1	66·7	2·3	2·2
Finest ,, ..	11·2	6·7	0·9	80·0	0·8	0·4
Corn meal	11·4	8·5	4·6	72·8	1·4	1·3
,, (fine) ..	12·5	6·8	1·3	78·0	0·8	0·6
Buckwheat flour ..	14·0	7·1	1·2	75·9	0·6	1·2
Rizine (flaked rice) ..	11·7	7·9	0·5	79·5	—	0·4

The exact proportion of these constituents contained in each cereal is represented in the tables, and in order of their relative richness in each the members of the group may be arranged thus:

Proteid.	Fat.	Carbohydrates.	Mineral Matter.
Oats.	Oats.	Rice.	Barley.
Wheat.	Maize.	Rye.	Millet.
Millet.	Millet.	Wheat.	Buckwheat.
Buckwheat.	Buckwheat.	Barley.	Oats.
Rye.	Rye.	Maize.	Rye.
Barley.	Wheat.	Millet.	Wheat.
Maize.	Barley.	Buckwheat.	Maize.
Rice.		Oats.	Rice.

The great **preponderance of carbohydrates** in all cereals indicates that they should not be eaten alone, but along with other foods richer in fat and proteid. This we have instinctively learned to do, and accordingly we mix eggs and milk with puddings, and spread butter on bread or eat it with cheese or meat. They are all rather deficient in building material, except, perhaps, oats, and none of them can be regarded as an important source of fat. As a group they are extremely well absorbed, ranking in that respect next to,

report on the composition of the cereals exhibited at the Columbian Exposition being freely used (United States Bulletin 45). The proteid has been calculated from the nitrogen, using the factor 5·7 for all except barley, maize and buckwheat, where the factor 6 was employed.

and in some cases even above, the animal foods, and this fact, combined with their compactness and richness in nutrients, places them in the front rank of human foods.

WHEAT.

In this country wheat is by far the most important of cereal foods. We are said to consume 6 bushels of it per head of the population every year. A food which is so largely used merits a detailed study.

If a grain of wheat be cut into thin slices and examined under a microscope, it will be found to consist of the following parts (Fig. 15):

1. The germ, or embryo. This is simply the young plant. It represents about $1\frac{1}{2}$ per cent. of the whole grain.

2. The kernel, or endosperm. This consists of two large masses of nutritive material for the use of the embryo. It makes up 85 per cent. of the grain.

3. The bran—an outer envelope mainly composed of cellulose impregnated with mineral matter, and designed as a protective covering to the grain, of which it makes up about $13\frac{1}{2}$ per cent.

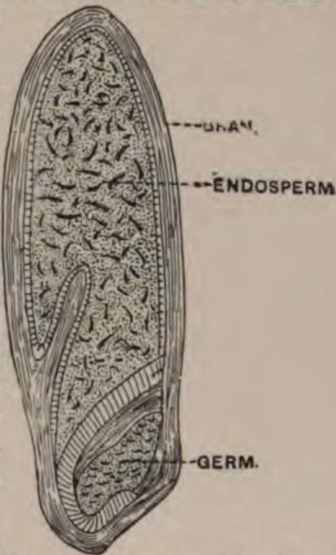

FIG. 15.—LONGITUDINAL SECTION THROUGH A GRAIN OF WHEAT (LOW POWER VIEW).

The chemical composition of the whole grain and of its three components is shown in the following table, constructed chiefly from analyses by Professor Church. It will be noticed that the germ is characterized by its richness in proteid and fat, the endosperm by an abundance of starch, and the bran by a preponderance of mineral matter and cellulose. It should be added that the germ is further peculiar in that both its proteid and its carbohydrates are chiefly present in a soluble form.

COMPOSITION OF THE DIFFERENT PARTS OF A WHEAT GRAIN.[1]

	Bran (13·5 per cent.).	Endosperm (85 per cent.).	Germ (1·5 per cent.).	Whole Grain (100·0 per cent.).
Water	12·5	13·0	12·5	14·5
Nitrogenous matter ..	16·4	10·5	35·7[2]	11·0
Fat	3·5	0·8	13·1	1·2
Starch and sugar ..	43·6	74·3	31·2[3]	69·0
Cellulose	18·0	0·7	1·8	2·6
Mineral matter	6·0	0·7	5·7	1·7

If the section of wheat be now **more highly magnified**, we can make out the structure of its various components in greater detail. One

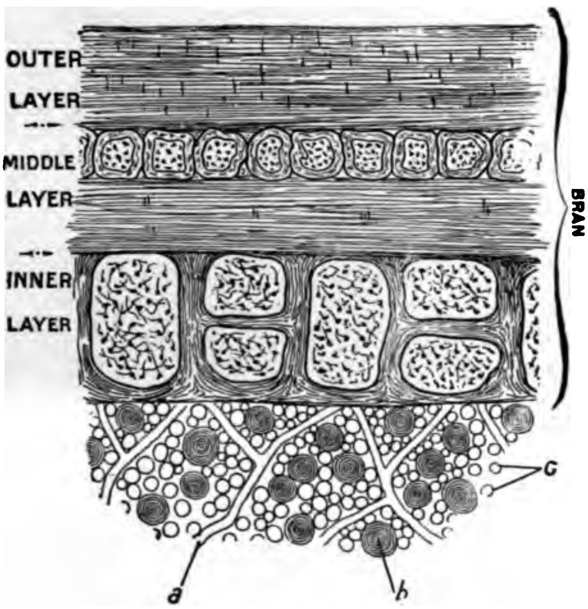

FIG. 16.—SECTION THROUGH PART OF A WHEAT GRAIN (MORE HIGHLY MAGNIFIED).

a, Honeycomb of cellulose; *b*, starch grains; *c*, particles of gluten.

can then see (Fig. 16) that the **endosperm** consists of a delicate honeycomb of cellulose, the cavities of which are crammed full of starch grains, the interstices being filled up by smaller particles consisting of a proteid or mixture of proteids called gluten. The

[1] The first three analyses are by Professor Church.
[2] The germ contains 6·44 per cent. of nitrogen, of which 0·80 gramme is in the form of amides (Frankfurt, *Landwirth. versuchs Stät.*, 1896, xlvii. 449).
[3] Most of this is in a soluble form.

gluten granules are most abundant in the outer zones of the endosperm.

The relative proportions of starch and gluten differ in different kinds of wheat. Generally speaking, it may be said that those grains which look hard, translucent, and horny on section, are rich in gluten and poor in starch; while for the grains which are soft, opaque, and floury on section, the reverse holds good.

The **bran** is found to consist of three distinct layers:

1. An outer layer consisting entirely of fibres of cellulose impregnated with mineral matter. This is the layer which is removed in the decortication of wheat.

2. A middle layer consisting chiefly of small cells full of pigment, which give to the bran its brown colour. This layer is much poorer in cellulose than the first.

3. An inner layer consisting of a single row of large cells full of a granular matter, which is a proteid termed *aleurone*. This layer is sometimes also called the 'cerealin' layer. It contains least cellulose of all.

The **germ** consists of a mass of small cells rich in proteid and fat, but its more minute structure does not concern us just now.

The wheat grain may be used as a food in its entirety. Soaked in water till it swelled up and burst, and then boiled in milk, with the addition of sugar and other ingredients, it formed the old and very nourishing dish called **frumenty**, which is now, however, but seldom seen on the table.

Far more commonly it is reduced before eating to a state of meal or flour by the process of **grinding or milling**. Now, it is an exceedingly difficult matter, owing to its toughness, to reduce the bran of wheat to a powder by grinding. It can be done, but the trouble and expense entailed are so great that one of the miller's first objects is to remove it altogether. In the old method of stone grinding the bran was removed, but the germ was left, the meal or flour consisting of the products of the germ and endosperm together. In the elaborate processes of modern roller milling, however, the germ also is removed, but for a different reason from the bran. It is found that the oil which is contained so abundantly in the germ is apt to become rancid, so spoiling the flour, while the soluble proteids which are present in that part of the grain are apt to act upon the starch of the flour, converting part of it into soluble forms (dextrin and sugar), which darken in colour in the oven and detract from the appearance of the bread. So the germ is got rid of also, its removal being facilitated by the fact that its toughness causes it to become

flattened out in the process of milling, while the more brittle endosperm is reduced to a fine powder, which can be separated by sifting.

Hence it comes about that in the process of milling, to which the whole grain is subjected, its different parts are broken up, various **mill-products** being produced. The outer coat yields 'bran,' 'fine pollards,' 'sharps' and 'middlings,' which represent different fragments of it from without inwards, the germ is removed as 'offal,' while the 'flour' is derived solely from the endosperm.

To the whole of the **flour** so derived the term 'straight-run' or 'straight-grade' is applied, and the yield of it is about 70 per cent. of the weight of the original grain. By mechanical processes this can be further divided into a small quantity of **patents**, and a large quantity of 'bakers' or 'households.' The former is derived from the central part of the endosperm, and if prepared from ordinary wheat is consequently rather poor in proteid, but very rich in starch. Some 'strong' wheats, however, *e.g.*, Australian, yield a 'patents' which is still rich in gluten; it is from such flour that genuine Vienna bread is made. Owing to its purity of colour, 'patents' is usually reserved for the preparation of fancy breads and pastry.

'**Households**' **flour** is further subdivided into (1) second patents, or 'whites'; (2) first households; (3) second households, or 'seconds.' The first of these is derived from the part of the endosperm nearest to that which produces 'patents'; the last emanates from the outer layers, just under the bran; while the first households comes from the intermediate part of the endosperm. Of these varieties, 'seconds' is richest in proteid (gluten), 'whites' in starch.

Ordinary bread is usually made from a mixture of 'whites' and 'households,' derived, most commonly, from a blend of different wheats.

A blend is used because wheats differ in composition, some being rich in gluten and poor in water ('strong' wheats), while others are more starchy and contain more moisture. Indian wheat, which has only about 8 per cent. of water, is an example of the first sort; most English wheats (14 per cent. moisture) belong to the second. The 'strong' wheats take up most water on baking, and hence yield most loaves. This is the explanation of the apparent paradox, that the larger the *bulk* of a sack of wheat, the smaller is the quantity of bread it is capable of yielding. Another advantage of blending is that the deficiencies of one kind of gluten are made up for by the excesses of another; for gluten is a composite substance, and some wheats are richer in some of its constituents, other wheats in others,

and by suitable blending a flour can be produced which is not only 'strong,' but has also a good colour and flavour.

'Seconds' flour yields a bread which is richer in proteid than the product of most blends; but the loaf is apt to be rather dark in colour, and on that account not highly appreciated by the public.

An **analysis** has been made by Church[1] of some of these **mill-products** of wheat, which brings out the difference in the proportion of proteid they contain, to which reference has been made above. Here are the figures:

Proteid.	*Per cent. N.*	*Per cent. Fat.*
Whole wheat	1·69	2·02
Flour ('patents')	1·62	1·4
,, ('seconds')	1·96	1·82
Bran	2·14	2·75
'Fine sharps'	2·60	3·50

It should be added that a considerable proportion of the nitrogen of 'sharps' is not in a proteid form.

Now, in rejecting the germ and the bran the miller undoubtedly discards some of the most useful chemical constituents of the wheat, for with the germ proteid and fat are lost, and with the bran mineral matter and the proteid contained in its layer of aleurone cells.

The recognition of this waste has led to the devising of two patent processes to prevent it. The first of these deals with the germ (Smith's patent). In this process the separated germ is partially cooked by means of superheated steam. This kills the ferment contained in the soluble proteids, which, as we have seen, acts upon the starch of the flour. Thus the danger of a dark loaf is obviated. The steam also sterilizes the fat of the germ, preventing it from becoming rancid, and so spoiling the taste of the flour. The germ so treated is ground to a fine meal, and of this one part is added to three of ordinary flour, the mixture constituting **'Hovis' flour**. It is, as one would expect, much richer in proteid and fat than ordinary flour (see table below). Since the discovery of this method of treating the germ, many similar processes have been introduced, and 'germ breads' are now of frequent occurrence in the market. The invention of them marks a decided advance in our methods of bread-making.[2]

The second patent process to which reference has been made deals with the bran. It is the **'Frame Food' process**. The bran is

[1] 'Food Grains of India,' p. 95.

[2] A liquid extract of the germ which contains its ferments has recently been introduced under the name of 'Eurissa.' It has much the same uses in bread-making as malt-extracts (see p. 197).

boiled with water under high pressure, the result of which is to break down most of its cellulose and to extract from it most of its mineral constituents and part of its nitrogen. A proportion of carbohydrate is also removed in a soluble form. The watery extract is filtered and evaporated under diminished pressure to dryness. In this form it constitutes 'Frame Food Extract.' It is rich in mineral matter and nitrogen, although much of the latter is probably not present in a proteid form. The extract so prepared forms the basis of various preparations manufactured by the Frame Food Company, to some of which reference will be made later.

The following table shows the comparative composition of the different preparations of wheat of which we have been speaking:

	Wheat-meal.	Medium Flour (Households).	Finest Flour (Patents).	Hovis Flour.	Frame Food Extract.
Water	12·1	12·3	13·8	12·2	9·8
Nitrogenous matter[1] ..	14·2	10·7	7·9	15·5	16·5
Fat	1·9	1·1	1·4	3·2	1·0
Carbohydrates (including cellulose)	70·6	75·4	76·4	70·0	63·9
Ash	1·2	0·5	0·5	2·3	8·8

Cookery of Flour—Bread.

In order to make flour available as food, it must be cooked in some way or another. The simplest method is to mix the flour with water and bake it. It is in this way that **ship's biscuit** is manufactured. The product, however, is of an almost flinty hardness, and not easy of mastication. Hence the problem early arose, how to cook the flour in such a way that it would be light and easy of digestion. The problem was solved by causing gas to develop in the mixture of flour and water, so converting the latter into a kind of sponge, which was subsequently baked, and into which the digestive juices can easily penetrate. In other words, man learnt to make **bread**. Now, the making of bread from flour is only possible because the latter contains gluten. Gluten is a proteid, or mixture of proteids, which has the peculiar property of becoming viscid when mixed with water. If the viscid mass is then blown up with gas, it has sufficient coherence to remain in the form of a sponge or honeycomb, instead of collapsing again, as it otherwise would do, and allowing the gas to escape. Most other cereals, such as barley, rice, and oatmeal, do not contain gluten, but other forms of proteid,

[1] $N \times 6.25$.

which do not become viscid when moistened, and consequently out of these bread cannot be made.

The next question is, How is the gas, which is to be used to blow up the dough, produced? The reply is that the earliest method of producing the gas, and that which is still by far the most widely used, was by **fermentation**. There are certain very minute plants, called yeasts, which are capable of breaking up sugar in such a way as to produce from it carbonic acid gas and alcohol. This process is one of 'fermentation' and may be represented by the following chemical formula:

$C_6H_{12}O_6$	=	$2CO_2$	+	$2C_2H_6O$.
(1 molecule of sugar)	yields	2 molecules of carbonic acid gas	and	2 molecules of alcohol.

The yeast is used to manufacture gas out of the sugar contained in the dough. But where does the yeast come from? In the old days—and leaven bread was known to the Egyptians in the time of Moses—it simply came from the air. Yeast cells appear to be floating about in the atmosphere, and when they meet with any soil on which they can grow they start there and produce fermentation. If dough, therefore, be left exposed to the air, yeast cells will ultimately find their way into it, and start to grow and multiply, and produce gas in the dough. But other minute plants, bacteria, get into the dough at the same time, and these produce acids in it (especially acetic and lactic acids),[1] so that the dough not only ferments, but becomes sour. It was this sour fermenting dough that was first used for making bread. It was called **leaven.** A little of it was added to fresh dough, and the yeast which it contained started to grow with great rapidity through the fresh dough till it was all 'leavened,' and filled with bubbles of gas. Most of this dough was then baked, but a small part was set aside as the 'leaven' to be used in starting fermentation in a fresh batch of bread. The presence of the acids in this leavened bread causes it to have a sour taste, and for this reason the process is now but rarely used. The black sour bread (pumpernickel) met with in North Germany is still made by a process of leavening.

The next advance upon this process, which must have been introduced after beer was known, was to use pure yeast obtained from the brewer, and thus to get the production of gas in the dough without the development of acids. In more recent years brewer's yeast has been gradually displaced by 'compressed' or 'German' yeast,

[1] For a more complete description of the changes which take place in dough under fermentation, see Weyl's 'Handb. d. Hygiene,' iii. 247.

which is more convenient and keeps better. It consists of pure yeast grown in a special way and purified by repeated washing, after which it is compressed into cakes.

In using yeast to make bread, the first thing the baker has to do is to get his yeast to increase and multiply. This has two advantages: it enables an originally small quantity of yeast to suffice for a whole sack of flour, and it produces a more active yeast, for the young cells are more energetic than those which are older. This stage of bread-making is called the preparation of the **ferment**. About 8 pounds or so of good potatoes are taken and boiled down to a thin sort of gruel; 2 pounds of flour are added, and then the yeast and the mixture is stirred up and kept at a temperature of 85° F. or thereabouts. The yeast derives abundant nourishment from the flour, and grows and multiplies very fast. The nitrogenous matter of the flour also acts upon the large starch grains of the potato, converting them in part into sugar, which is straightway attacked by the yeast. After about five hours or so the process comes to a standstill, but the whole ferment is now swarming with young and active yeast cells. A quarter or a third of a sack of flour is now taken and thoroughly mixed with the ferment and some water in a trough. The potato-skins are kept back, of course, and a small quantity of salt—about ½ ounce for each quartern loaf—is usually, but not always, added. The salt acts as a sort of check on the fermentation. This mixture is spoken of technically as the **sponge**. The young yeast cells now act upon the sugar produced from the flour, and alcohol and carbonic acid gas are liberated all through the sponge. The gas blows the latter up, and after the lapse of about five hours the top breaks and some of the gas escapes. After another hour has elapsed it again breaks, and when this has happened the rest of the sack of flour is added along with some more water. In all about 60 quarts of water are used for every sack of flour. This constitutes the **dough**. It is thoroughly mixed by machinery, and then left for an hour to 'rise.' At the end of that time it is weighed and placed in the oven for one and a half hours at a temperature of about 450° F. This treatment causes the gas in the dough to expand and blow the latter up so that it becomes full of little cavities. The heat also hardens and coagulates the proteids of the flour in the outer part of the loaf, where the temperature is highest. Some of the starch is converted into soluble starch and dextrin, and forms the crust. It is to the dextrin that the crust owes its glazed appearance. Altogether about 8 per cent.[1]

[1] Bull. 67, United States Department of Agriculture, 1899.

of the starch in the loaf is thus converted. Some caramel also is formed, and helps to give the crust its flavour and dark colour. When these changes have taken place the dough has passed into the form of bread. A whole sack of flour (280 pounds) yields under the above method of treatment about ninety-six quartern loaves. In other words, 1 pound of bread can be obtained from about $\frac{3}{4}$ pound of flour, 25 per cent. of water being taken up in the dough.

It must not be supposed that the method of bread-making is everywhere precisely identical. The above is the process as practised in London, but the details vary somewhat in different localities. Thus, some bakers add the ferment to the whole of the flour right away. Others omit the ferment stage, and begin by making a 'sponge,' which is afterwards added to the dough.

Scotch bakers prepare first a 'barm,' which is a mixture of malted flour, sugar and hops, and from this make their 'sponge.'[1] They also add more salt than is usual here; hence the more marked flavour of Scotch bread.

Now, it will be obvious that any process of making bread by fermentation necessarily implies a certain amount of waste. Some, at least, of the starch in the flour is lost by being split up first into sugar, and then into alcohol and carbonic acid gas. The gas is of no use from a nutritive point of view, and the alcohol is mostly driven off by the heat of the oven. It has been calculated by Graham[2] that 300,000 gallons of alcohol are annually lost in this way in the ovens of London alone. A patent was taken out more than fifty years ago for collecting this alcohol, but the process did not pay in practice. A small quantity of this alcohol does remain in the bread, perhaps about 16 grains in each loaf. In a paper in the *Chemical News* (1873) it was computed that forty 2-pound loaves contain as much alcohol as a bottle of ordinary port. Bolas found 0·22 to 0·40 per cent. alcohol in new bread.

Jago[3] states that in all about 1·3 per cent. of the nutritive ingredients used in bread-making are lost in the course of the operations. Very exact observations on this point have been made in a bakery at Pittsburg. It was found that 1·3 per cent. of the proteids, 71·2 per cent. of the fats, and 3·2 per cent. of the carbohydrates in the ingredients disappeared in the process of baking. The total loss of nutritive material, reckoned in Calories, was about 5 per cent. The very great loss of fat is striking, and has been

[1] See 'Practical Bread-making,' by F. T. Vine; London, 1897.
[2] 'Chemistry of Bread-making,' Cantor Lectures, 1879.
[3] Jago, 'Science and Art of Bread-making.'

confirmed by observations made at New Brunswick,[1] in which the fat in the original flour had diminished nearly 60 per cent. by the time the bread was completed. It would appear that the fat is volatilized by the heat of the oven.

Fully fifty years ago experiments were made in Glasgow by Dr. Dundas Thomson, which showed that a sack of flour would yield 107 loaves of unfermented bread, and only 100 loaves of fermented bread.[2]

The consideration of this inevitable waste has led to attempts to convert dough into a porous form by other methods than that of fermentation. One of these is the method of Dauglish. In this process the gas is prepared from chemical substances. Water is saturated with it, and is mixed with the flour under pressure in air-tight chambers. The pressure in these is then lowered by opening a trap, and the dough is forced out and blown up by the expanding gas. It is next cut into loaves, and the rest of the baking is quickly completed in the usual way. The product is known as **aerated bread.** It is quite as porous as that produced by fermentation, but is found by some people to have a rather 'raw' and insipid taste. This is apparently to be attributed to the absence of certain bye-products which yeast produces in the course of its growth. Hence, the bread has not met with universal favour, in spite of its more economical mode of production. The process would appear to be specially suited for the making of wholemeal bread, for it deprives the proteids of the bran of the opportunity of converting some of the starch of the flour into soluble forms, to which soluble substances much of the moistness and heaviness of ordinary wholemeal bread is to be attributed.

Results similar to the above are also obtained by the use of **baking-powders.** These consist of mixtures of various chemical substances, which have this in common, that when moistened the ingredients of the powder act upon one another, carbonic acid being given off. If, therefore, the powder has been thoroughly mixed with the flour, and water be added, the gas will be liberated all through the resulting dough, and the latter will be thoroughly aerated. A *Lancet* Commission, which inquired into the composition of these powders a few years ago,[3] reported that the majority of them were pure, consisting of a mixture either of tartaric acid or

[1] Voorhees, United States Department of Agriculture, Office of Experiment Stations, Bull. 53; see also *ibid.*, Bull. 67.
[2] 'The Food of Animals,' p. 183; London, 1846.
[3] *Lancet*, March 3, 1894.

bitartrate of potash with bicarbonate of soda. A few of them, however, contained alum, and these leave some alumina, or, more probably, hydrated oxide of aluminium, in the bread. The tartaric acid powders are the most efficient, for they give off twenty-five times their volume of gas; the cream of tartar powders yield only thirteen volumes, and alum powders not more than seven to eleven. In all of these powders the soda is slightly in excess, so that the end reaction of the chemical process is alkaline. There is thus no possibility of their rendering the bread sour. 'Self-raising' flour is flour with which baking-powder has already been mixed.

No matter by what process a loaf is made, it possesses, when finished, certain characters by which bakers judge of its quality. It should be well 'risen,' and possessed of a thin flinty crust, which is neither very light nor very dark in colour, and cracks on breaking. The crumb should be elastic in consistence, of uniform texture without large holes, and of a smooth and silky 'pile.' It should have a sweet, nutty flavour and odour, and in colour should be of a creamy whiteness. Curiously enough, when bakers speak of a loaf having 'no colour,' they mean that it is rather dark, whereas 'high colour' signifies with them great whiteness. It must be admitted, however, that the above characters, however important æsthetically, are not of much value from a nutritive point of view. Especially is this so in regard to colour. A very white loaf means a loaf in which starch is at a maximum and proteid at a minimum, and that is certainly not desirable. For setting up a false standard of whiteness the baker is not to blame. It is the ignorance of the public, which mistrusts a dark loaf.

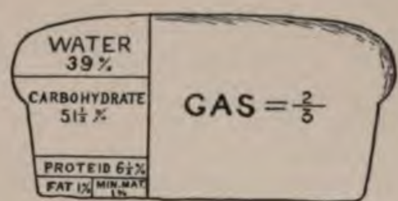

FIG. 17.—DIAGRAMMATIC REPRESENTATION OF THE COMPOSITION OF A LOAF.

THE CHEMICAL COMPOSITION OF BREAD.

Two-thirds of the volume of a good loaf is made up of gas[1] (Fig. 17), and of the solid part about 40 to 50 per cent. by weight consists of water, so that bread is one of the least watery of vegetable foods, and is relatively much less so than raw meat. The

[1] See Lehman, *Archiv f. Hygiene*, xxi. 215, 1894.

composition of the dry residue will obviously depend upon that of the flour from which the bread has been made. Especially has one to consider whether the bran and the germ have been left in the flour or not. In white bread these have been excluded. As regards 'brown' breads one cannot speak so definitely, for the term **brown bread** is a vague expression. It may simply mean that a certain proportion of bran or of germ or of both have been added to the flour, or it may be applied to bread made from whole wheat meal. In each case the resulting loaf will be 'brown.' Now, bran contains, as we have seen, a good deal of mineral matter and proteid. One would naturally expect, therefore, that bread containing bran should be richer in these ingredients than white bread. As regards mineral matter this is certainly true, but it is by no means invariably true of proteid. The following table shows in round numbers the mean

COMPOSITION OF WHOLEMEAL AND WHITE BREAD COMPARED.

	White.	*Wholemeal.*
Water	40·0	45·0
Proteid[1]	6·5	6·3
Fat	1·0	1·2
Starch, sugar and dextrin	51·2	44·8
Cellulose	0·3	1·5
Mineral matter	1·0	1·2

percentage composition of several white and wholemeal breads analyzed by the writer, and it will be noticed that the proteid is really more abundant in the white bread. These results are confirmed by the following analyses by Atwater:[2]

	Water.	*Proteid.*	*Mineral Matter.*
White bread	35·4	9·5	1·1
Brown bread	40·0	5·0	1·9
Graham bread	32·3	8·5	1·5

Bell also says:[3] 'Contrary to the views sometimes put forward by the advocates of the use of wheatmeal bread, the samples of household flour submitted to analysis were found richer in nitrogenous matter than the entire wheat grain.' In some recent studies of breads made in America,[4] the following conclusions were arrived at:

1. Seventeen samples of bread from 'bakers' and 'patents' had 9½ per cent. proteid.

[1] N × 5·7. According to Rubner, only 72 per cent. of the nitrogen of bread is in a proteid form.

[2] 'Chemical Composition of American Food Materials.'

[3] 'Analysis and Adulteration of Foods.'

[4] Bull. 67, United States Department of Agriculture (Office of Experiment Stations).

2. Bread from imitation whole wheat flour had less proteid than the above. That from true wholemeal (*i.e.*, no germ removed) had 1 per cent. more.

It must be added that these breads were apparently considerably drier than ours (32·9 and 33·8 per cent. water respectively). The authors add that no conclusions can be drawn from these figures regarding their nutritive value.

The difference in brown bread is partly due to the amount of water present. The 'proteid' of the bran converts some of the starch into dextrin, and this keeps the brown bread moist. In carbohydrates brown bread is decidedly poorer than white. Not only so, but about 2 per cent. of the carbohydrates consists of the comparatively useless cellulose.

There are also various **fancy and patent breads** in the market. Of the former the different varieties of **Vienna bread** are a good example. These are made from very fine flour ('patents') fermented with compressed yeast, milk being often added to the dough. The crust is glazed by being subjected to the action of overheated steam before leaving the oven. Of the **patent breads**, the majority are of the 'brown' variety. They are made from flours prepared by various patent processes. Some of them are wholemeal breads, in which the **bran** has been reduced to varying degrees of fineness; others contain the **germ** in various proportions, of which 'Hovis' is the best-known example. Others, again, are **malted**. The malting of bread consists in adding to it malt-extract, obtained by evaporating an infusion of malted barley to a syrupy consistency at a low temperature. The solid part of the malt-extract so prepared consists mainly of malt-sugar and dextrins. But it also contains the ferment diastase, which is able to convert starch into soluble substances (maltose and dextrin). When, therefore, malt-extract is mixed with the dough part of the starch, the latter is ultimately converted into malt-sugar and dextrin. In other words, part of the starch is digested. This has the effect, as already pointed out, of making the bread keep longer moist. Now, it is important to remember that this ferment diastase is readily killed if exposed to a high temperature. Hence its activity inevitably ceases whenever the bread enters the oven. If, then, any considerable part of the starch of the dough is to be converted, the malt-extract must be added very early in the process. As an alternative to that it may be added to a separate part of the flour, and the latter mixed with water and kept at a moderate temperature till most of its starch has been changed, and this mixture added to the dough just before baking. This is the

COMPOSITION OF SOME SPECIAL BREADS.[1]

	Water.	Proteid.	Mineral Matter.	Carbo-hydrates and Fat.	Characteristics.
'V. V.' bread	40·4	7·5	0·59	51·6	Vis Vitæ is a very good white bread, containing little water, but remaining long moist. It is made of flours rich in proteid, and fermented with a specially pure yeast.
Maltina white bread	44·5	5·9	0·7	48·9	A good white bread. Does not contain any malt. Fermented with distiller's yeast.
Nevill's " "	37·5	7·2	0·7	54·6	A good white bread, fairly rich in proteid.
Triagon " " (O'Callaghan's)	39·0	6·4	0·7	53·9	An excellent white bread, containing some malted rice and maize flour, and some added phosphoric acid.
Hony white bread	46·8	5·7	0·58	46·8	Kermode's patent. A fancy bread from fine flour, part of the starch of which has been converted by the addition of malt. Not rich in proteid. Remains long moist. Contains some maize.
Cyclone wholemeal bread	47·9	7·1	1·4	43·6	A wholemeal bread of average fineness. The meal ground by the cyclone process. About 8 per cent. of it escapes digestion (*Goodfellow*).
Opmus bread	43·0	6·5	1·3	49·2	A fine wholemeal bread, containing a considerable proportion of germ and little cellulose. Made from Opmus flour (John Thompson and Son's Patent).
Seatree's bread	43·4	6·8	1·1	48·7	A brown bread made from Seatree's brown flour, derived from strong British and Duluth wheats, containing malt and germ. Bran very finely ground and outer layer removed Cellulose amounts to about 2·2 per cent of the dry constituents. The waste is 8½ per cent. (*Goodfellow*).
Manhu bread	42·6	7·2	1·3	48·9	A bread made from whole wheat flour of superior quality. Very rich in nitrogen. Cellulose in a state of fine division.
Triticumina bread	43·6	7·3	1·5	47·6	A brown bread made from desiccated wholemeal flour and malted wheat bran in a state of very fine division (Meaby's patent). The dry matter contains about 3½ per cent. of cellulose. About 7½ per cent. of the bread escapes digestion (*Goodfellow*).
Nevill's wheatmeal [bread	41·5	8·0	1·2	49·3	A moderately fine wholemeal bread, rich in proteid.
Maltina brown bread	45·1	7·0	1·9	46·0	A wholemeal malted bread, containing a good deal of rather coarse fibre.
Daren " "	46·6	7·9	1·0	44·5	A malted brown bread of good texture, composed of wheat flour, ryemeal and germ. Rich in nitrogen. Cellulose small in amount.
Cytos " " (Marshall and Son's)	42·3	8·1	1·3	48·3	A brown bread composed of wheat flour with a considerable proportion of germ and malt. Cellulose small in amount.
Bermaline brown bread (Montgomerie's patent)	38·0	8·1	1·9	50·3 1·7 (Fat)	A malted brown bread, containing about 10 per cent. of soluble carbohydrates. Comparatively rich in fat. Cellulose small in amount.
Hovis brown bread	45·0	9·9	1·2	42·3 1·6 (Fat)	Richest in nitrogen of all breads. Cellulose small in amount. Ash very rich in phosphoric acid; waste only slightly above that of ordinary white bread (*Goodfellow*).
Vagos bread	46·0	7·7	1·2	45·1	A malted bread containing a certain proportion of germ. No bran.

[1] In analyzing these breads the nitrogen was estimated by Kjeldahl's process, and the proteid calculated from it, using the factor 5·7. The ash was determined in the usual way. The carbohydrates were estimated by difference. Only a few fat estimations were made, the fat being usually included in the carbohydrates owing to the small amount of it present, and its unimportance as a nutritive constituent of bread (it may be taken to be usually less than 1½ per cent.). The bread was analyzed in each case on the day after baking

peculiarity of Montgomerie's process, by which 'Bermaline' bread is made. But even under these favourable conditions not much more than 10 per cent. of the carbohydrates of the loaf are in a soluble form, while in ordinary bread about 4 per cent. is so changed. Seeing, also, that the diastase is killed by the act of baking, it is obvious that malted bread cannot be truly said to *aid* the digestion of other starchy foods. In the preceding table the composition of most of the patent breads is shown from analyses made by the author. The special peculiarities of each kind are also briefly indicated. We shall consider the nutritive and economic value of these breads later. The comparative composition of the **crust and crumb** of white bread is given by Barral as follows:

	Crust.	*Crumb.*
Water	17·15	44·45
Insoluble proteid	7·30	5·92
Soluble ,, ...	5·70	0·75
Dextrin and sugar	4·88	3·79
Starch	62·58	43·55
Fatty matters	1·18	0·70
Ash	1·21	0·84

The most striking point about these figures is the much larger proportion of solids in the crust, and the larger amount of soluble proteids and carbohydrates which it contains.

Changes which Bread undergoes on Keeping.

When bread is kept it becomes dry from loss of water. The loss, however, is not a very rapid one. The following are the average results of fifty observations by Goodfellow: [1]

	A 2-lb. Loaf loses	*Loss per cent.*
In 12 hours	$\frac{2}{7}$ oz.	0·9
,, 24 ,, ...	$\frac{5}{8}$,,	2·0
,, 36 ,, ...	$1\frac{3}{5}$,,	5·0
,, 48 ,, ...	$2\frac{14}{25}$,,	8·0
,, 60 ,, ...	$3\frac{1}{2}$,,	11·0
,, 72 ,, ...	$4\frac{1}{2}$,,	14·0

At the end of a week 14 per cent. of the original water is gone, and after a month 18 per cent. (v. Bibra). The bread also becomes stale. The **staleness** is not entirely due to the loss of water, for, as was long ago shown by Boussingault, one has merely to heat the loaf up again to a temperature of about 300° F. in order to restore much of its freshness. Yet in the course of this rebaking it loses considerably more water than it had already lost by evaporation.

[1] 'Dietetic Value of Bread,' p. 139.

The explanation of this rather surprising result is not yet clear. It may be that in fresh bread there is some free water present, which becomes united with starch or gluten as the bread grows stale, and that the rebaking sets it free again. That is the explanation of v. Bibra,[1] who has also shown that the freshness will not return if the bread has already lost 30 per cent. of its water. Mattieu Williams,[2] on the other hand, believes that the staling of bread is due to the shrinkage and coming together of the fibres which form the walls of its visible pores. The water vapour generated by the rebaking drives these fibres apart again.

In former days, when good flour was more expensive, **adulterants** used often to be added to bread. Of these alum was one of the most harmful. Flour which has been produced from badly ripened grain, or which has been kept for some time under bad conditions, does not form good dough. This is owing to a too great solubility of its proteids. Alum seems to unite with these so that they become insoluble, and the dough regains its toughness and power of holding water. Sulphate of copper and lime act similarly, and by the aid of these substances an inferior flour could be used for bread-making.

Fortunately, these adulterations appear to be things of the past, and it is comforting to learn that 'it is now certain that the bread supplied to the people of England is practically pure' (Goodfellow).

The **cooking of bread** is practically confined to the application of dry heat. This has the effect of driving off water, and of rupturing some of the starch grains, and converting them partly into soluble starch and dextrin. A little caramel also is produced. The result is toast. 'Pulled bread' is made by pulling out the interior of a new loaf and thoroughly baking it. The same changes occur in it as in toast, only to a greater degree.

Biscuits are made from fine flour either alone or with the addition of sugar, butter, milk, flavouring agents, etc. Baking-powder is sometimes added to make them rise a little. They contain very little water (about 5 per cent.), and 3 pounds of them may be taken as equal in nourishment to 5 pounds of bread (Church). The following table shows an analysis of some by Bauer:

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[1] V. Bibra, 'Die Getreidearten und das Brot' Nürnberg, 1860; see also Lehmann, *Archiv. f. Hygiene*, xxi. 215, 1894.

[2] 'Chemistry of Cookery,' p. 209.

COMPOSITION OF BISCUITS.

	Fine Wheaten Biscuits.	Other Wheaten Biscuits.	English Biscuits.
Water	1·18	10·07	7·45
Nitrogenous matter	13·31	11·93	7·18
Fat	3·18	7·47	9·28
Sugar	7·12	36·38	17·02
Other carbohydrates	73·96	32·29	58·08
Cellulose	0·25	0·75	0·16
Mineral matter	1·0	1·14	0·83

Rusks may be regarded as a kind of toast. They are made in much the same way as bread, but with the addition of butter, sugar and milk, and are twice passed through the oven, after which they are thoroughly dried.

In the next chapter we shall consider the digestibility and nutritive value of bread.

CHAPTER XII

BREAD (*continued*)—OTHER CEREALS

DIGESTIBILITY AND ABSORPTION OF BREAD.

THE digestion of bread takes place, in part at least, in the mouth, by the conversion of its starch into dextrins and maltose under the action of the saliva. The more thoroughly bread is chewed and ground into particles, the more complete will the transformation of the starch be. It is on account of the greater ease with which they can be pulverized by the teeth that toast and biscuits are more easily digested than ordinary bread and stale bread than a newly-baked loaf. The dryness of toast and biscuits, too, enables them to become easily saturated with the saliva, and that also greatly facilitates digestion. Further, it must be remembered that a considerable proportion of the starch in biscuits and toast has been already converted into soluble forms in the course of their preparation, so that the labours of the digestive juices in their case are considerably lightened. It is for these reasons also that the crust of bread is more digestible than the crumb, for the former is drier, and contains a higher proportion of soluble carbohydrates than the latter, owing to the more intense action upon it of the heat of the oven.

The notorious indigestibility of new bread, on the other hand, is due to its moistness, which makes it difficult to chew, and at the same time prevents it from soaking up the saliva.

As regards the **duration of its stay in the stomach**, bread occupies a middle position among the vegetable foods, 70 grammes (an ordinary slice) having completely left the stomach in two hours and twenty minutes, while 150 grammes (two rather thick slices) remain about an hour longer. These periods cannot really be regarded as long when one bears in mind the comparatively large amount of solid matter which bread contains.[1] White bread is disposed of by

[1] Penzoldt, *Deut. Archiv. f. Klin. Med.*, li. 535, 1893.

the stomach rather more quickly than black (*e.g.* pumpernickel), but there is no appreciable difference in this respect between the behaviour of wholemeal bread and that made from fine flour. The presence of bran in wholemeal bread, however, may act as ballast in the stomach, and give to it the greater 'sustaining' power with which it is commonly credited. Considering the large amount of solid nutriment which they contain, biscuits must be regarded as considerably more digestible than ordinary bread.

New bread, unless very thoroughly chewed, offers greater resistance to the stomach than stale bread, owing to its tendency to form doughy masses.

In the intestine the digestion of the starch and proteid of bread is completed, and **absorption** takes place. On the whole, white bread is very thoroughly absorbed. Even when large quantities are consumed, the loss of nutritive constituents is only about as follows :[1]

	Percentage unabsorbed.
Total solids	$4\frac{1}{2}$
Proteid	20
Mineral matter	25
Carbohydrates	3

It will be noted that the greatest share of loss falls to the proteids, of which about one-fifth escapes absorption. This contrasts very strikingly with the case of meat, in which the proteid is absorbed almost in its entirety.

The **defective absorption of the proteids** in bread is apparently due in part to the large amount of starch present ;[2] in part, also, it may be only apparent, and explicable by the fact that bread requires a large production of the digestive juices for its complete solution (see also p. 10).

The above experiments apply to cases in which bread formed the main part of the diet. When given along with other foods, its absorption appears to be considerably increased. Thus, five experiments on an exclusive bread diet showed an average absorption of 82 per cent. of the proteid and 99 per cent. of the carbohydrates. When 2 litres of milk were added to the diet, the absorption of proteid rose to 97 per cent., while that of the carbohydrates remained stationary. Ten experiments on milk alone showed a proteid

[1] From the average of a considerable number of experiments by Rubner, Atwater, Zuntz and Magnus-Levy, Goodfellow and others. The quantities consumed were very considerable, amounting to from 600 to 1,000 grammes per day.
[2] See experiments by Meyer, *Zeit. f. Biolog.*, Bd. 7, p. 1, 1871.

absorption of 92 per cent., and an absorption of the carbohydrates to 86⅓ per cent.[1]

This is another instance of the general rule, that a mixture of foods is better absorbed than any one food by itself.

The **carbohydrate** of bread corresponds to the proteid of meat in being almost completely absorbed into the blood. On the other hand, it is rather surprising to find that, of the comparatively small amount of **mineral matter** met with in bread, one-fourth is excreted unabsorbed. Seeing that this is the case, it is surely futile to recommend the use of bread containing a larger amount of mineral constituents.

Relative Absorption of White and Wholemeal Bread.

Brown and wholemeal breads differ from white bread, as we have already seen, in containing more or less of the bran of the wheat. Any difference which they show in absorbability, therefore, when compared with white bread, will probably depend on this peculiarity.

Now, **bran** contains a large amount of cellulose, some analysts placing the proportion as high as 20 per cent. or more.[2] Not only so: the cellulose of bran is in a dense and woody form. It has already been pointed out that, at the best, cellulose is but imperfectly digested by man, and that when it becomes woody it is hardly digested at all. Hence one would expect the constituents of bran, enclosed as they are by woody cellulose, to be but indifferently absorbed. Experiment fully justifies this expectation. Donders[3] observed that the walls of bran cells were digested by herbivora, but not by man; and Giraud was able to demonstrate the aleurone cells in the human excreta unchanged—an observation which has been more recently confirmed by Moeller.[4] Pozziale,[5] too, found that bran, which had originally contained 13 per cent. of nitrogenous matter, still retained fully 3½ per cent. after traversing the digestive apparatus of two dogs and a hen. One is therefore not surprised to learn that Rubner[6] found that only one-third of the nutriment contained in bran is capable of being made use of by the human digestive organs.

[1] Bull. 53, United States Department of Agriculture, Office of Experiment Stations, p. 43.

[2] Lebbin, *Archiv. f. Hygiene*, xxviii., 212, 1897.

[3] Quoted by Meyer, *op. cit.*

[4] *Zeit. f. Biolog.*, Bd. 35, 291, 1897. This writer gives an exhaustive summary of the results of previous workers upon the digestion of various cells as tested by microscopical examination of the stools.

[5] Quoted by Meyer, *op. cit.*

[6] *Zeit. f. Biolog.*, xix. 45, 1883.

Seeing that, of the total amount of mineral matter which wholemeal bread contains, fully 65 per cent. belongs to the bran, one would expect the mineral constituents of such bread to be specially singled out for defective absorption. And this is so. Fully half of them never enter the blood at all (Rubner, Goodfellow, and others). The carbohydrates, too, of wholemeal bread are not so completely absorbed as those of white bread, more than 5 per cent. being lost.[1] Some observers, indeed, have found a greater difference between the absorption of wholemeal and white bread in respect of this constituent than in regard to any other.

The results of observations on the absorption of the *proteids* of wholemeal bread are by no means unanimous. Some experimenters (*e.g.*, Goodfellow) have found but little difference between the behaviour of wholemeal and white bread in this respect, while others (*e.g.*, Meyer), comparing whole wheat bread with moderately fine rye bread, have found a difference of 10 per cent. or more in favour of the latter.

Some of the most conclusive experiments on this point may be cited here. Rubner[2] compared the relative absorption of bread made from the three following flours:

1. Finest white flour ('patents').
2. Middle quality ('seconds').
3. 'Wheatmeal flour.'

In making the loaves, the directions of the Bread Reform League were followed. Upwards of 600 grammes of the bread were eaten daily, the amount of nutrients contained in each case being as follows:

	Nitrogen.	*Fat.*	*Carbo-hydrates.*	*Mineral Matter.*
No. 1.	10·20	6·69	528·8	2·39
„ 2.	13·19	5·65	507·9	2·85
„ 3.	12·45	12·65	504·5	8·54

Bread No. 1 contained 68·5 per cent. water; No. 2 had 69·4 per cent.; No. 3, 62·4 per cent. The *percentages of loss* from non-absorption were these:

Bread.	Quantity of Dry Substance eaten.	Percent. Dry Substance lost.	Percent. N lost.	Percent. Fat lost.	Percent. Carbo-hydrate lost.	Percent. Ash lost.
No. 1.	615·3 grammes	4·03	20·07	44·69	1·10	19·28
„ 2.	612·6 „	6·66	24·56	62·83	2·57	30·35
„ 3.	617·1 „	12·23	30·47	51·14	7·37	44·98

[1] Moeller, however (*Zeit. f. Biolog.*, xxxv., 1897), states that he could find no starch cells in the fæces even when Graham bread was eaten. Notwithstanding this, he decides the question of wholemeal versus white bread entirely in favour of the latter.

[2] *Zeit. f. Biolog.*, xix. 45, 1883

The *absolute* losses were:

	Fresh Fæces.	Dried.	N.	Fat	Carbohydrates.	Ash.
No. 1.	132·7	24·8	2·17	2·99	5·83	2·39
„ 2.	252·8	40·8	3·24	3·55	13·10	3·90
„ 3.	317·8	75·7	3·80	6·47	37·23	8·34

He draws special attention to the great absolute loss of carbohydrate in the wholemeal bread.

More recent experiments have been made in America,[1] in which the absorption of bread made from 'patents' and 'bakers'' flour respectively was studied, 672 grammes of bread being taken daily. The results were:

Bread.	Percent. digested. Dry Matter.	Proteid.	Fat.	Carbohydrates.
'Bakers''	94·2	91·0	94·6	96·8
'Patents'	94·4	90·5	94·7	96·9

No difference was found in this case between the two kinds of bread. Taking the results as a whole, it may fairly be concluded that the proteid of wholemeal bread is not so well absorbed as that of white bread. Even bread made from decorticated wheat does not offer the advantages often ascribed to it, for exact experiment has shown that it is not much better absorbed than ordinary wholemeal bread.[2]

The **defective absorption of wholemeal bread** is no doubt to be attributed to the large amount of **cellulose** which it contains. The cellulose acts chiefly by preventing the access of the digestive juices to the nutritive ingredients which are enclosed in it. It is also sometimes said to interfere with absorption by hurrying on the contents of the intestine by the stimulating influence which it exerts on peristalsis. This would appear, however, to be an error, for Rubner found[3] that, on the whole, the fæces on a coarse bread diet were more slowly evacuated than those of fine bread. On the other hand, the residue of wholemeal bread seems more prone to undergo fermentation, with the production of acids, and it is to this that the greater wateriness of the wholemeal bread fæces is to be attributed, for the intestine endeavours to neutralize the acids by a greater flow of alkaline fluid. It is probably for this reason that wholemeal bread interferes somewhat with the absorption of other foods. Thus, Goodfellow[4] has found that the waste in milk is greater by 3 per cent. when given along with wholemeal bread than when

United tates Department of Agriculture, Office of Experiment Stations, Bul. 67.

[2] Menicanti and Prausnitz, 'Untersuchungen über das Verhalten verschiedener Brotarten im Menschlichen Organismus' (*Zeit. f. Biolog.*, xxx. 328, 1894).

Op.

[4] 'Dietetic Value of Bread,' p. 199. In this work will be found numerous experiments on the absorption of wholemeal bread.

taken alone. This, as we have seen, is the very reverse of the effect exercised by ordinary bread.

Taking the mean results of available experiments, one may contrast **the absorption of the constituents of white and wholemeal bread** thus:

	White Bread.	*Wholemeal Bread.*	
Total solids	4½ per cent.	14 per cent.	lost.
Proteids	20 ,,	20 to 30 ,,	
Ash	25 ,,	51 ,,	
Carbohydrates	3 ,,	6 ,,	

These results, which were all obtained from observations on healthy human beings, are entirely confirmed by experiments on the digestibility of bread in the laboratory by means of artificial juices. By this method Brunton and Tunnicliffe[1] found that sugar is produced much more rapidly from white bread than from brown, and that 14 per cent. more of the nitrogenous matter was dissolved in the former case than in the latter. Goodfellow,[2] by a very similar method, had already obtained the same result.

It might reasonably be contended that the defective absorption of the constituents of bran is due to imperfect grinding, and that if the bran were reduced to as fine a powder as the flour it would be as well digested as the latter. To some extent this is true, and brown breads made from finely ground patent wholemeals are unquestionably better digested than the ordinary coarse brown bread. Observations by Romberg,[3] however, on the digestion of rye bread, show that, no matter how well ground the bran is, it is never as well absorbed as the flour. He prepared a series of breads from rye, the meal used being in each case of equal *fineness*, but differing in the proportion of bran contained. Thus, bread No. 1 consisted of the flour only and was perfectly white, while No. 4 was made from the whole grain and was very dark; Nos. 2 and 3 were of intermediate quality. The following tables show the composition of the *meals* used and the percentages of *waste* in the digestion of the corresponding breads:

COMPOSITION OF THE MEALS.

		In Dry Substance.			
	Water.	*Proteid.*	*Fat.*	*Ash.*	*Carbohydrate.*
No. 1.	11·25	7·43	0·99	0·49	91·09
,, 2.	11·84	11·59	1·14	0·92	86·35
,, 3.	11·26	17·28	2·13	1·89	78·70
,, 4.	11·40	16·84	2·13	2·22	78·81

1 'St. Bartholomew's Hospital Reports,' xxxiii. 157, 1897.
2 'Dietetic Value of Bread,' pp. 183, 184.
3 Romberg, *Archiv. f. Hygiene*, Bd. 28, p. 244, 1897.

PERCENTAGES UNDIGESTED IN THE CORRESPONDING BREADS.

	Dry Substance.	Proteid.	Ash.	Carbo-hydrates, etc.
No. 1.	4·15	22·0	58·8	1·66
„ 2.	7·51	28·6	75·5	4·15
„ 3.	13·64	30·5	74·4	8·08
„ 4.	20·07	43·0	61·9	14·40

Seeing that the ingredients of the bread were in an equally fine state of division in every case, the author concludes that even bran *flour* is not suitable for human food, and that no method of preparing it will make it as capable of being absorbed as white flour.

The absorption of wholemeal bread has been dwelt upon at considerable length, for reasons that will be apparent when we come to consider its nutritive value. As regards the digestibility and absorption of bread in general, it only remains to be added that there is some reason to suppose that custom plays a considerable part in it, and that people who are habitually large bread-eaters acquire the power of digesting it more completely than those who are not so habituated to its use.[1]

Nutritive Value of Bread.

Weight for weight, though not bulk for bulk, bread must be regarded as one of the most nutritious of our ordinary foods. This is due largely to the fact that three-fifths of it consist of solid nutriment, and but two-fifths of water, and there is no animal food and but few *cooked* vegetable foods of which the same can be said.

Of the chemical constituents necessary for proper nutrition, bread yields to the blood a large proportion of carbohydrates, a moderate amount of proteid and mineral matters, but almost no fat. The fact that bread is usually eaten with butter, however, renders the absence of fat a consideration of but little importance.

Yet bread cannot be regarded as a perfect food. The proportion of proteid to carbohydrate is too low. An ideal food would contain one part of proteid to 4·2 parts of carbohydrate, whereas in white bread the proportion is only 1 to 8½. In order to obtain from bread the proteid requisite in an ordinary diet, one would require to eat a whole 4-pound loaf every day, and that would contain more than twice as much carbohydrate as one really requires. To the ordinary mixed feeder this does not matter, for he makes good the deficiency of proteid by adding to the bread a 'proteid-carrier' such as meat, milk, or cheese. Where bread forms the staple article of diet, however, as it does in many poor households, this lack of proteid

[1] See Rubner, *Zeit. f. Biolog.*, xv. 154.

must be regarded as a serious drawback. Various methods of overcoming it have been tried, all of which consist in adding to the flour some other highly nitrogenous substance. **Peasemeal** has been used with this object, and when added to flour in equal proportions is said to make a good loaf. **Skim milk** has also been employed. A loaf made entirely with skim milk had the following composition when compared with a loaf made from the same flour and water :[1]

	Milk Loaf.	*Water Loaf.*
Water	31·29	32·59
Proteid	9·73	8·75
Carbohydrate	56·66	56·65
Fat	0·96	0·86
Ash	1·39	1·15

Meat has also been proposed as an addition, 2 pounds of flour and 1 pound of cooked minced meat making a good and digestible loaf, which, with the addition of fat, is almost a complete food.

More elaborate methods are by the addition of **Aleuronat or casein.** Aleuronat was introduced by Dr. Hundhausen. It is simply gluten prepared in a special way, and contains 80 per cent. of proteid. It occurs as a colourless, odourless powder, which is well digested and absorbed, and when added to flour in the proportion of 1 part to 3 yields a loaf containing nearly 20 per cent. of proteid, and at a cost but little above that of ordinary bread.[2] The addition of casein is employed by the Protene Company in their household Protene bread, 25 per cent. of casein being added to ordinary flour. The resulting loaf is very rich in proteid, but is necessarily rather expensive.

It must be admitted that none of these methods of increasing the amount of proteid in bread is altogether adapted for ordinary use, and that they are all apt to make the cost of the bread too great. Perhaps one or other of the **germ breads** now in the market, of which Hovis is the best example, meets the requirements better than any substitute which has yet been proposed. About 3 pounds of such a bread would supply all the proteid required daily, and would only contain a slight excess of carbohydrate. With the free addition of butter or some other fat, it is not far from being a complete food. Unfortunately, there are not many experiments available to determine whether or not the 'germ' is well absorbed. Goodfellow[3] has given some attention to the matter,

[1] Sartori, quoted by Stutzer, Weyl's 'Handbuch der Hygiene,' iii. 251.
[2] Carl Voit, *Archiv. f. Hygiene*, xvii., 408, 1893.
[3] 'Dietetic Value of Bread,' p. 255.

however, in the case of Hovis bread, and found that the loss was only very slightly above that of ordinary white bread.

Putting aside such patent breads, which are all apt to be rather expensive, it may be said that white bread made from 'seconds' flour will yield more nitrogen to the body than a bread made of ordinary flour, and still more than one made of 'patents.' The reasons for this have already been discussed.

When we pass on to consider the **relative nutritive values of white and wholemeal bread**, we are on ground which has been the scene of many a controversy. It is often contended that wholemeal is preferable to white bread, because it is richer in proteid and mineral matter, and so makes a better-balanced diet. But our examination of the chemical composition of wholemeal bread has shown that, as regards proteid at least, this is not always true, and even were it the case, the lesser absorption of wholemeal bread, which we have seen to occur, would tend to annul the advantage. As regards mineral matter, we have seen that even in the case of ordinary bread this is not all absorbed, while the absorption is so much less in wholemeal bread that, as regards the amount of mineral matter yielded to the blood, the two are about on an equality. There is, therefore, no justification for recommending the use of wholemeal bread by growing children or nursing women.

On the whole, we may fairly regard the vexed question of wholemeal versus white bread as finally settled, and settled in favour of the latter, and had due regard been paid to the behaviour of bread in the intestine instead of merely to its chemical composition, the Bread Reform League would probably never have come into existence.

ECONOMIC VALUE OF BREAD.

Bread is not only one of the most nutritious, but it is also amongst the cheapest of foods. In an earlier chapter we saw that for a given sum one obtains a larger number of Calories from bread than from any other food. As regards the actual amount of dry nutriment obtained, bread also heads the list. Thus,

A pennyworth of	bread	yields	.. ..	8	oz. of dry nutriment
,,	oatmeal	,,	.. ..	7½	,, ,,
,,	lentils	,,	.. ..	5½	,, ,,
,,	potatoes	,,	.. ..	5⅓	,, ,,
,,	rice	,,	.. ..	5¼	,, ,,
,,	cheese	,,	.. ..	2¼	,, ,,
,,	carrots	,,	.. ..	2	,, ,,
,,	fish	,,	.. ..	1	,, ,,
,,	meat	,,	.. ..	0⅛	,, ,,

(Goodfellow.)

Or if one looks at the matter from the point of view of the number of grains of carbon and nitrogen obtained for a given sum, one gets the following results:

		Carbon.	Nitrogen.
A pennyworth of oatmeal contains	..	1,887 grammes	90·0 grammes
" rice "	..	1,366 "	34·0 "
" bread "	..	1,180 "	70·0 "
" lentils "	..	1,079 "	99·0 "
" potatoes "	..	1,025 "	29·0 "
" cheese "	..	418 "	38·0 "
" beef "	..	185 "	18·4 "

(Goodfellow.)

Taking proteid alone as our standard, we find that bread is a fairly cheap source even of that constituent. Thus,

1 pound of proteid costs in the form of flour	.. ..	5¼d.
" " " maize	.. ..	6d.
" " " beans	.. ..	7d.
" " " oatmeal	.. ..	7½d.
" " " bread	.. ..	1s. 2d.
" " " cheese	.. ..	1s. 3½d.
" " " rice	.. ..	1s. 5d.
" " " milk	.. ..	2s. 2½d.
" " " beef { cheapest	..	1s. 4½d.
best	..	4s. 5d.
" " " eggs	.. ..	5s. 0½d.

Cheap food though it be, bread is dear when compared with the cost of flour. As a matter of fact, it has been found that bread costs just twice as much as the ingredients required to make it;[1] in other words, half of the cost of a loaf represents the value of the baker's trouble and time. It follows from this that, where economy is important, it would be cheaper to bake one's own bread at home than to buy it from the baker.

Of the patent and fancy breads as a whole, it may be said that they are relatively somewhat dearer than white bread. About 1½d. per pound may be regarded as their average cost. Even ordinary brown bread has ceased to be cheaper than white, and cannot therefore be recommended on that ground.

I may conclude this subject in the words of Dr. Goodfellow:[2] 'It will be perfectly clear . . . that bread is one of the cheapest foods, not only with regard to the actual weight of nourishment obtained, but also with regard to the variety of the nutrient constituents; and the purchaser who expends his modest 2½d. on a 2-pound loaf may rest assured that he could not spend his money to better advantage, except, perhaps, in the purchase of oatmeal, which contains slightly more energising nutriment than bread.'

[1] See Bull. 52, United States Department of Agriculture (Office of Experiment Stations).

[2] 'Dietetic Value of Bread,' p. 106.

Bread has been dwelt upon at some length on account of its great practical value. The other food-stuffs derived from wheat may be dismissed more briefly.

Semolina is prepared from the central part of hard wheats which are rich in gluten, and is largely used in the South of Europe. It contains about 11 per cent. of proteid, or half the amount contained in an equal weight of beef. It must thus be regarded as a fairly nitrogenous vegetable food, and is useful for making puddings, porridge, thickening of soups, etc.

Macaroni, vermicelli and the Italian pastes are also made from flours rich in gluten. The flour is made into a paste with water, and the viscidity of the gluten then allows it to be moulded in various ways or drawn into tubes. It is afterwards dried or slightly baked.

Macaroni and vermicelli absorb about three times their weight of water in the process of cooking, so that the product when eaten, although highly nutritious, is about eight times poorer in nitrogen than a similar weight of beef.

Macaroni and vermicelli are absorbed almost in their entirety.[1] Their use is therefore indicated in conditions where it is advisable to leave behind as small a residue as possible in the intestine.

The following table represents the composition of these and some similar preparations from recent analyses by Balland:

COMPOSITION OF ITALIAN PASTES, ETC.[2]

	Water.	N Substances.	Fat.	Starch, etc.	Cellulose.	Ash
Macaroni (1895) ..	11·60	10·98	0·45	76·05	0·28	0·64
,, (1897) ..	12·00	10·89	0·65	75·70	0·26	0·50
Vermicelli (1896) ..	10·90	11·74	0·50	75·74	0·38	0·74
,, (1897) ..	10·00	12·51	0·80	75·51	0·28	0·90
Pâtes d'Italie (1897) ..	10·40	12·51	0·80	75·23	0·30	0·76
Semolina (1895) ..	9·20	13·50	0·85	75·45	0·50	0·50
,, (1896) ..	9·20	10·42	0·55	78·63	0·45	0·75
,, (1897) ..	10·50	11·96	0·60	75·79	0·50	0·65
Rice semolina (1898) ..	10·80	7·34	0·30	80·96	0·40	0·20
Foreign tapioca (1897)	12·80	0·00	0·20	86·88	0·08	0·04
French potato tapioca (1897)	16·00	0·45	0·15	82·95	0·00	0·45

The following are some **patent preparations of wheat**:

Granose[3] is a partially cooked preparation which occurs in the form of flakes. It contains 12 per cent. of moisture, 13·3 per cent.

[1] Rubner, *Zeit. f. Biolog.*, xv. 165, 1879.
[2] Balland, *Journ. Pharm. Chim.*, 1898, p. 328; *Analyst*, 1898, p. 178
[3] Health Food Co., Battle Creek, Michigan, U.S.A.

of proteid, and 2 per cent. of mineral matter. It may be regarded as an easily digested form of wheat, as the starch grains have been partially ruptured by the heating to which it has been subjected.

Granola is a whole-wheat preparation manufactured by Mr. James Marshall in this country.[1] The same maker produces a granular preparation of the endosperm of wheat under the name of **Farola.**

Florador is another wheat product of recent introduction, and in a granular form. It contains 10·6 of proteid and 0·3 per cent. of mineral matter, and is recommended for use in the making of blanc-mange, etc. It is undoubtedly far more nutritious than such preparations as cornflour, which are so commonly used for a similar purpose.

Shredded wheat[2] is an ingenious preparation of whole wheat in the form of shreds or flakes, which have been cooked to the consistence of a biscuit, and represents the whole grain in a very digestible form. **Chapman's whole wheat flour** is described at p. 449.

Other Cereals: Oats.

Oats may be regarded as the most nutritious of all cereals. They are rich in nitrogenous matter and mineral substances, and are peculiarly rich in fat, the only other cereal which can at all compare with them in that respect being maize. Starch is present to the extent of about 38 per cent. Further, of the total nitrogenous matter, 94 per cent. is in the form of proteid, and therefore available for tissue-building. Unfortunately, the husk of oats is closely adherent, and cannot be entirely separated from the kernel, so that by the ordinary methods of grinding a good deal of cellulose is left in the meal in the form of small sharp particles. These act as stimulants to the intestine, and make oatmeal a valuable food where the intestinal movements are sluggish, but, on the other hand, are apt to prove rather irritating to some persons.

Oatmeal is also found to be a 'heating' food in the case of some individuals, and one sometimes sees the development of skin eruptions follow its use. This 'heating' effect is said not to be due to the large amount of proteid which it contains, but to a special constituent to which the name 'avenin' has been given.[3] Similar 'stimulating' results are often observed in horses which are liberally supplied with oats. It must be stated, however, that the existence of this substance is denied by many observers. There are various

[1] 25, East Cumberland Street, Glasgow.
[2] Shredded Wheat Co., St. George's House, Eastcheap, E.C.
[3] Sanson, *Comptes Rendus*, xcvi., p. 75, 1883.

ways of preparing oats for human food. It may be simply cleaned and ground, the result being **oatmeal** of various degrees of fineness, or the branny particles may be separated, and the 'oat flour' alone used. **Groats** consists of oats from which the husk has been entirely removed; when crushed, Embden groats results.

Rolling has recently begun to be employed as a method of preparing oats, instead of grinding. The great pressure to which the grains are subjected between the rollers ruptures the cell walls, breaks down the cellulose, and flattens the grains out so that they are more easily softened by cooking. By the application of heat during the rolling process, the grains are at the same time partially cooked. This not only has the advantage of rendering subsequent preparation for the table considerably less laborious, but also alters the fat, which is so abundantly present in oats, in such a way that it is less liable to become rancid, so preserving the natural flavour of the grain.

'Quaker Oats' is one of the best known of these preparations. 'Waverley Oats,' 'Provost Oats,' and Montgomerie's 'Berina' are examples of Scotch rolled oats. 'Avenine' is a similar product. The composition of some special preparations of oats is shown in the following table:

PREPARATIONS OF OATS.

	Scotch Oatmeal.	Irish Oatmeal.	'Quaker Oats.'	Carter's Oats.	'H-O.'	Montgomerie's Fine Oatmeal.	Scott's Oat Flour.	Robinson's Groats.
Water ..	5·0	5·0	7·8	3·1	9·0	6·3	5·8	10·4
Proteid	14·6	13·4	14·7	12·9	13·8	11·0	10·0	11·3
Fat ..	10·1	8·8	6·2	6·2	8·3	6·8	5·0	6·5
Carbohydrates	65·1	68·4	69·8	76·0	67·2	74·2	77·9	70·4
Cellulose	3·1	1·7						
Mineral matter	2·1	2·0	1·5	1·8	1·7	1·7	1·3	1·7

It will be observed that the finer the product the poorer it is in nitrogenous and mineral matters. In this respect oat flour bears the same relation to oatmeal as fine wheat flour does to whole wheatmeal.

Owing to the absence of gluten, oatmeal is unfitted for bread-making, and is usually simply mixed with water and made into cakes. By mixing fine oatmeal with an equal quantity of wheat flour, however, a fairly good loaf can be obtained. A given weight of oatcake (made without butter) contains rather more than twice as much building material as an equal quantity of bread, and has almost twice as great a fuel value.

Oatmeal requires to be very thoroughly boiled in order to soften the cellulose which it contains. 'Brose,' which is made by merely stirring oatmeal into boiling water, is not a food for delicate stomachs. No experiments have been made on the digestibility and 'absorbability' of oatmeal in man. One would expect that there must be a considerable amount of waste, especially of nitrogen, owing to the high proportion of cellulose, and this may considerably lower the real nutritive value of oatmeal as an article of diet. On purely chemical grounds, oats compare very favourably with wheat as a source of nutriment. A **soup-plateful of porridge** made with 'Quaker Oats' contains 64 grammes of oats, and has the following amount of nutrients:

Proteid	9·4	grammes
Fat	3·9	"
Carbohydrates (including cellulose)	44·6	"
Mineral matters	0·9	"

To obtain as much proteid one would require to eat two slices of a 4-pound loaf ¾ to 1 inch thick, but one and a third of such slices would yield as much fuel as the porridge. If the bread were spread with butter, it would be equal in fuel value to a plateful of porridge and ⅓ pint of good milk. As regards mineral constituents, the plateful of porridge and the slice and a third of bread are almost exactly equal.

Maize (Indian Corn).

Maize is not so largely used as human food in this country as it should be, but throughout America it forms a staple article of diet, while in Mexico and Natal maize is literally the 'staff of life' (Letheby). It was introduced into Ireland at the time of the potato famine in 1848, and has since established a place for itself in the dietary of the people, so that Ireland now imports more of it for food purposes than any other European country.

Chemical analysis (see Table, p. 183) shows that maize is fully as nutritious as wheat in all except its mineral ingredients, while it is richer in fat than any cereal except oats, containing twice as much of this important constituent as wheat or barley, and three times as much as rye. In nitrogenous matter it is slightly inferior to most other cereals, but fully 87 per cent. of this is in a proteid form. As regards its digestible carbohydrates, it is equal to wheat, but somewhat inferior to barley or rye.

Maize is prepared for food in many different ways. In Ireland it is made into a sort of porridge, called *stirabout*, or, in the more expressive phraseology of America, *mush*. In Northern Italy and

the South Tyrol it is prepared in a similar way, but with the addition of cheese and other ingredients. Maizemeal is prepared by grinding after removal of the germ and husk. A yellow and a white meal are thus prepared, but there is no difference between these as far as nutritive value is concerned. Fine maizemeal is more gritty than wheat flour, but when mixed with the latter its presence can hardly be detected. The comparative cheapness of maize flour is an inducement to millers to adulterate wheat flour with it, and this is already being done to some extent in America and France. Flour so adulterated yields fewer loaves than an equal quantity of pure wheat flour, and the bread produced is moister than wheaten bread, and has a tendency to be sodden. An addition of 10 per cent. of maize flour is calculated to mean a reduction of five loaves on the sack. Owing to the absence of gluten, this meal cannot be used to make ordinary bread, but it is often baked into cakes of various sorts. The *johnny* (corruption of 'journey') *cakes* of North America are unleavened, and are made of a rather coarse maize-meal. Similar cakes constitute the *tortilla* of South America. The following is the composition of johnny cakes[1]:

Water	38·0 per cent.
Proteid	8·5 ,,
Fat	2·7 ,,
Carbohydrate	47·3 ,,
Mineral matter	3·5 ,,

If one compares this with the analysis of good white bread, given on p. 196, it will be seen that the comparison is all in favour of maize.

Sometimes the maizemeal is leavened with yeast and subsequently baked in iron vessels. In this form it is known as *pone*, while in Ireland baking-powder is used, or the maizemeal is mixed with flour and so converted into loaves. One-third of its weight of good flour is sufficient to enable fine maizemeal to form good loaves. The colour of the bread is always rather dark, however, even if the proportion of wheat flour used be increased to one-half.

Various **special preparations of maize** deserve mention. *Hominy, cerealine* and *samp* are preparations of broken or split maize of various degrees of fineness. The composition of the first two is as follows:

	Hominy.[2]	*Cerealine.*[3]
Water	11·9 per cent.	10·6 per cent.
Proteid	8·2 ,,	9·4 ,,
Fat	0·6 ,,	1·0 ,,
Carbohydrates	78·9 ,,	78·6 ,,
Mineral matter	0·4 ,,	0·4 ,,

[1] Analysis by Atwater and Wood. [2] Analysis by the author.
[3] Analysis by Atwater and Wood.

Both preparations are of high nutritive value and admirably adapted for making puddings, etc.

Cornflour, *maizena* and *oswego* are prepared from maize by washing away the proteid and fat by means of dilute alkaline solutions, so that little but starch is left. Church states that cornflour contains only 18 grains of proteid in every pound, and a sample of Brown and Polson's cornflour which the writer examined showed a mere trace of nitrogen. The following is an analysis of *maizena*:[1]

Water	14·3 per cent.
Proteid	0·5 ,,
Carbohydrates	84·9 ,,
Mineral matter	0·3 ,,

These preparations must therefore be regarded simply as agreeable forms of starch, well adapted for food, provided they are taken along with some proteid and fat carrier, such as eggs or milk, but by no means to be recommended on economic grounds.

A special small variety of maize is called in America *pop-corn*. When roasted it swells up and ultimately bursts, and in this form is known as 'popped pop-corn,' and is the basis of various sweets. Its composition is as follows:[2]

	Pop-corn (*Raw*).	*Pop-corn* (*Popped*).
Water	10·8 per cent.	4·3 per cent.
Proteid	11·2 ,,	10·7 ,,
Fat	5·2 ,,	5·0 ,,
Carbohydrates	71·4 ,,	78·7 ,,
Mineral matter	1·4 ,,	1·3 ,,

It is thus a valuable food.

Sugar-corn is a special variety of maize, containing much sugar. It is cooked while still green, and forms a sweet and succulent vegetable much esteemed in America.

Maize is not only a highly nutritive cereal from the chemist's point of view, but has the further advantage of being very well digested in the human body. Experiments show that 90 per cent. of its dry matter is absorbed, as compared with 82 per cent. in the case of wheat. Of the proteid of maize, 19·2 per cent. escapes absorption;[3] in wheat about 20 per cent. is lost.

Maize must undoubtedly be regarded as a food of **great nutritive value**. 'With a diet of Indian corn bread and pork,' says an American writer,[4] 'the workmen of this country are capable of enduring the

[1] Given by Klemperer in Leyden's 'Handbuch der Ernährungstherapie,' p. 298.
[2] Analysis by Atwater and Wood.
[3] Rubner, *Zeit. f. Biolog.*, xv. 115, 1879. See also experiments by Malfatti, quoted by König.
[4] United States Department of Agriculture, Div. of Chemistry, Bull. 50, p. 11.

greatest fatigue and performing the greatest amount of physical labour.'

It is also an **economical food.** It has been calculated[1] that when maize and wheat are both selling at the same price per bushel one gets the same amount of digestible matter for one's money in both. In wheat, however, one gets 2½ pounds more proteid, and in maize 2½ pounds more carbohydrate. The fuel value in each case is almost precisely the same.

In view of these facts and of the approaching scarcity of wheat, one cannot help a feeling of regret that maize is not more widely adopted as food amongst the lower classes in this country. 'The cry of Europe,' says C. J. Murphy,[2] 'is "cheap bread"; it is a bitter, agonizing cry, and we may best respond to it by instructing the toiling masses of the Old World in the excellence and cheapness of maize, and the proper methods of preparing it.'

BARLEY.

Barley is chiefly characterized by its richness in mineral matter. It contains more fat than wheat, but is comparatively poor in proteid. The amount of starch in it varies in different samples from 39 to 57 per cent. (O'Sullivan). The whole grain when ground constitutes barleymeal. Scotch barley is the grain stripped of its husk and roughly ground. It is chiefly used as human food, however, in the form of either 'pearl' or 'patent' barley. The former consists of the whole grain polished after removal of the husk; the latter is simply pearl barley ground into flour. The composition of these preparations is shown in the Table (p. 184), and the following is an analysis of Robinson's Patent Barley by Leeds:

Moisture	10·10 per cent.
Proteid	5·13 "
Fat	0·97 "
Carbohydrates	81·87 "
Mineral matter	1·93 "

Barley contains but little gluten, in consequence of which its dough is too 'heavy' to make good bread. When mixed with half its weight of good wheat flour, however, barleymeal can be converted into good enough loaves.

Writing on the nutritive value of barley in 1872, Letheby said: 'Barleymeal is the chief food of a large number of people in the

[1] United States Department of Agriculture, Division of Chemistry, Bull. 50, p. 14.

[2] 'Report to United States Department of Agriculture on the Use of Maize in Europe,' p. 6.

North of Europe and in the South of England, where the labourer is partly paid his wages in meal or grain. It is also used in Wales and Scotland, especially in winter-time, when wheaten bread is dear, and to some extent in Ireland. It is employed by about 90 per cent. of the out-door labouring population of England. At the time of Charles I. (1626), according to M'Culloch, it was the usual food of the ordinary sort of people, and as late as the middle of the last century hardly any wheat was used in the Northern counties of England. In Cumberland the principal families used only a small quantity of wheaten bread about Christmas-time. The crust of the everlasting goose-pie, which adorned the table of every county family, was invariably made of barleymeal.'

Since this was written barley has been steadily more and more displaced by wheat as an ordinary article of diet, and no doubt with considerable nutritive advantage.

As an article of diet in the sick-room, barley finds its chief use as the main ingredient of **barley-water**, a preparation which contains, however, but very little nutriment, as the following analysis by Wynter Blyth shows:

Water	99·27	per cent.
Fat	0·02	„
Proteid	0·03	„
Starch	0·39	„
Sugar	0·05	„
Mineral matter	0·03	„

It is chiefly of value on account of its demulcent properties.

Rye.

Next to wheat, **rye** is the great bread-making grain of the world. It contains less gluten than wheat, and the kind of gluten seems to be also chemically different, and it is as a result of this that the bread derived from rye is apt to be rather moist and dense. An extreme example is the black bread, or pumpernickel, of North Germany.

The composition of the different flours derived from rye varies very considerably with the fineness of milling; but fine rye flour is much poorer in proteid than flour of a similar grade produced from wheat.[1]

Fine rye bread is therefore poorer in building material than wheaten bread, but is somewhat superior in this respect to bread made from maize.

[1] *Vide* Falke, *Archiv. f. Hygiene*, xxviii., p. 49, and Romberg, *ibid.*, p. 244.

The **digestibility** of fine rye bread is about equal to that of good wheaten bread; but the coarser varieties, especially pumpernickel, are very wasteful foods, 32 per cent. of the proteid even in moderately fine rye bread being lost, as compared with 20 per cent. in white bread. In the case of pumpernickel the loss rises to 42 per cent.

Rice.

Rice is the poorest of all cereals in proteid and fat. On the other hand, it has fully 76 per cent. of starch. The starch has the further advantage of being present in small and easily-digested grains. When boiled, rice swells up and absorbs nearly five times its weight of water, while some of its mineral constituents are lost by solution. It is preferable, therefore, to cook it by steaming. Boiled rice has the following composition:[1]

Water	52·7 per cent.
Proteid	5·0 "
Fat	0·1 "
Carbohydrates	41·9 "
Mineral matter	0·3 "

Rice is only moderately easy of **digestion** in the stomach, 2½ ounces cooked by boiling (*i.e.*, about two-thirds of a full soup-plateful) requiring three and a half hours for its disposal. This is probably to be attributed to the fact that it is not the function of the stomach to digest carbohydrates.

On the other hand, rice is **absorbed** with very great completeness in the intestine; indeed, its solid constituents enter the blood almost as completely as those of meat. Practically none of the starch is lost, but the waste of proteid amounts to 19 per cent.[2] It follows from this that rice is one of the foods which leave the smallest residue in the intestine, and this gives it a considerable value in some cases of disease.

The nutritive value of rice is much impaired by its poverty in proteid and fat. Hence it is not adapted as an exclusive diet, but should be eaten along with other substances rich in these two elements, such as eggs and milk. Even as regards carbohydrate it would require about 1 pound 3 ounces of rice to furnish the daily need of an active man. This would entail the consumption of about 5 pounds of *cooked* rice daily.

[1] Analysis by Atwater and Woods.
[2] See Kumagawa, *Virchow's Archiv.*, cxvi. 370, 1889.

Millet and Buckwheat.

These cereals[1] are not used as human food in this country, although they are by no means of low nutritive value, but stand midway in that respect between wheat on the one hand and rice on the other. Millet is freely consumed in Africa, being the staple diet of the negroes of the Upper Nile, and in some Southern European countries, while in China it is used to make bread. The dhoora (sorgho-grass), or Indian millet, is of very similar composition. The following is an analysis of it given by Professor Church:

Water	12·2	per cent.
Proteid	8·2	„
Fat	4·2	„
Carbohydrates	70·6	„
Cellulose	3·1	„
Mineral matter	1·7	„

Buckwheat (see Tables, p. 184) is about equal in nutritive value to millet, but contains much more cellulose (10 per cent.). It is usually eaten in the form of a porridge. In this country it is hardly ever used as human food, but it is freely consumed in Brittany and Holland, and in some parts of the United States.

[1] Buckwheat is not strictly a cereal, but belongs to the Polygonaceæ. It is considered here for convenience.

CHAPTER XIII

THE PULSES—ROOTS AND TUBERS

The Pulses.

In this group are included peas, beans, and lentils, and their allies. The edible parts of these resemble the grain of cereals in that they are to be regarded as storehouses of nourishment for the young plant. The chief chemical characteristic of the group is the **richness** of its members **in nitrogen**, in virtue of which fact they have been described as 'the poor man's beef.' Only from 3 to 5 per cent. of the total nitrogen, moreover, is in a non-proteid form (Church). Why the young pulse should require so much more nitrogen than the young cereal, it would be difficult to say, but perhaps it is on account of its greater rapidity of growth. It may be remembered that there is a special provision for the adequate supply of nitrogen to plants of this group in the form of little nodules on their roots, which nodules consist of masses of bacteria, possessed of the remarkable power of fixing the free nitrogen of the atmosphere and passing it on for the use of the plant.

The chief proteid found in the pulses is called **legumin**,[1] also spoken of sometimes as vegetable casein, owing to its close resemblance to the principal proteid of milk. So much is this the case, that a kind of cheese may actually be prepared from beans. Legumin is able to unite with salts of lime, and the resulting compound is not soluble in water. It is for this reason that peas and other pulses do not readily soften if the water in which they are soaked contains much lime, *i.e.*, is hard. The addition of a little bicarbonate of soda to the water throws down the lime. Hence the importance of adding soda to hard water in which pulses are to be soaked. Magnesia, which resembles lime in so many other respects, has no effect upon legumin.[2]

[1] A nucleo-albumin (*Maly's Jahres-Bericht*, 1897, p. 21).
[2] See Strümpell, *Deut. Archiv. f. Klin. Med.*, Bd. 17, p. 108, 1876.

The proteids of some of the pulses seem to be specially rich in sulphur, and this, by giving rise to sulphuretted hydrogen gas, helps to explain their tendency to produce flatulence. Beans are richer in sulphur than peas, while lentils contain least of all. The ash of the pulses is poorer in phosphorus than that of the cereals, but richer in potash and lime. The pulses, indeed, contain more of the latter ingredient than any other form of vegetable food, and it has been stated that persons who live largely upon them, *e.g.*, the Trappist monks, are specially apt to suffer from early calcification of the arteries.

The pulses are well supplied with carbohydrates, but are poor in fat. For this reason they go well with fatty foods (*e.g.*, bacon and beans, pork and pease pudding), and are improved by being served with sauces containing butter. The only additional chemical fact concerning them which requires mention is that they contain a bitter principle which renders them unpalatable to many persons. Dried peas and beans require prolonged soaking in order to soften their skins. Even haricots, in which the skin is comparatively thin, require about eight hours to soften. The water in which they are soaked should be soft or boiled. The reason for this was given above. The soaking is inevitably accompanied by a certain loss of proteid and mineral matter, and also of carbohydrates; but it has the advantage of removing most of the bitter principle in the seeds. The amount of water taken up is very great. The proportion of water in dried haricot beans, for example, rises as the result of soaking and boiling from 14 per cent. up to 73 per cent., and in the case of peas the increase is from 9·7 up to 86·9 per cent.[1] This increase in water means, of course, a corresponding increase in the weight and bulk of the food, and must always be taken into account when comparing the relative nutritive values of the pulses and meat.

The pulses are **not readily digested** by the stomach. This is no doubt partly owing to their bulkiness when cooked. Thus, 5⅓ ounces (150 grammes) of lentils in the form of a mash, or about a soup-plateful, remain in the stomach for four hours, and 200 grammes of peas in a similar form remained for four hours and a quarter. An equal weight of French beans (haricots verts) took rather longer even than that.

If properly prepared, the pulses are **absorbed** in the intestine very thoroughly. Thus the proteid of pea or lentil flour is all taken up except about 8 or 9 per cent.[2] when 200 grammes are given daily.

[1] Analyses by Katherine J. Williams, *Journ. of Chem. Soc.*, lxi. 226, 1892.
[2] Strümpell, *Deut. Archiv. f. Klin. Med.*, Bd. 17, p. 108, 1876.

Even when the amount given was as much as 600 grammes, the loss was only as follows :[1]

Dry substance	9·1 per cent.
Proteid	17·5 "
Carbohydrate	3·6 "
Mineral matter	32·5 "

This shows that the proteid of the pulses, if given in a state of fine division, is capable of very good absorption—almost as good, indeed, as that of gluten when given in the form of macaroni, in which the loss is 11·2 per cent., and considerably better than gluten when taken in the form of white bread (loss about 20 per cent.). On the other hand, the loss is very much greater if the food is not given in a state of fine division. It was found, for example, that if the lentils were simply boiled soft and taken along with broth, the loss of proteid rose to 40 per cent.[2] It will be noted that there was a small loss of carbohydrate even on pea flour. The amount of it, however, is less than in the case of potatoes or carrots, but in white bread, it will be remembered, there is no loss of carbohydrate at all.

The **nutritive value of the pulses** is undoubtedly high. Especially is this the case if they be regarded as sources of proteid. It would require about 600 grammes (1⅓ pounds) of pea flour to supply the amount of proteid required daily by an active man. Suppose this were to be given in the form of pea soup. A good thick soup would contain 25 grammes—a heaped tablespoonful—in each plate. The proteid value of this would be equal to an ounce of meat. Twenty-four platefuls of such a soup, then, would require to be taken in the day. By making the soup with milk instead of water—an excellent plan—the amount of proteid in it would be trebled, and eight platefuls would suffice.

The 600 grammes of pea flour would hardly, however, contain as much carbohydrate as is required, and would be very deficient in fat. These deficiencies would require to be made good by the addition of some other articles to the diet, or by increasing the amount of pea flour consumed. As a matter of fact, it has been found that when the quantity of peas eaten amounts to 960 grammes in the twenty-four hours, all the demands of nutrition are satisfied ;[3] but it is very doubtful whether anyone could go on consuming this quantity for any length of time. It comes then to this, that, while the pulses are most valuable sources of proteid, they are not adapted to be the exclusive diet of health. As a cheap and efficient method

[1] Rubner, *Zeit. f. Biolog.*, xvi. 119, 1880. [2] Strümpell, *loc. cit.*
[3] Rubner, *loc. cit.*

of supplementing the deficiency of nitrogen in a purely vegetable diet, however, their use is strongly to be recommended, and it is a pity that they are not more largely taken advantage of by those to whom economy is of importance, for unquestionably the pulses are amongst the cheapest of foods, and a given sum will yield more proteid, if invested in these, than in any other way (see Plate III.). It remains to add a few words about the individual members of the pulse group. Their chemical composition is shown in the following tables:

COMPOSITION OF PULSES.

(From the Means of Many Analyses.)

	Water.	Proteid.	Carbohydrates.	Fat.	Cellulose.	Mineral Matter.
Green peas	78·1	4·0	16·0	0·5	0·5	0·9
Dried ,, ...	13·0	21·0	55·4	1·8	6·0	2·6
Lentils	11·7	23·2	58·4	2·0	2·0	2·7
Horse beans (dry) ..	13·1	25·5	50·9	1·7	5·5	3·3
Broad or Windsor beans (dry)	8·4	26·4	58·6	2·0	1·0	3·6
French beans (haricots verts)	89·5	1·5	7·3	0·4	0·6	0·7
Haricots (haricots blancs)	11·7	23·0	55·8	2·3	4·0	3·2
Haricots (cooked) ..	73·6	4·4	20·8 (and Cellulose)	0·5	—	0·7
Scarlet runners (stewed)	91·12	1·7	3·7	0·3	2·9	0·3
Soy beans	11·0	32·9	28·7	18·1	4·4	4·9
,, bean flour	9·3	39·5	28·2	13·7	4·0	5·3
Peanuts	8·3	24·0	17·0	44·3	4·5	1·9
Butter beans (ground unpeeled)	10·5	20·6	62·6	2·0	—	4·3

The following represents some recent analyses of pulses by Balland.[1]

	Beans (Haricots).		Lentils.		Peas.	
	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.
Water	10·00	20·40	11·70	13·50	10·60	14·20
Proteid	13·81	25·16	20·32	24·24	18·88	23·48
Fat	0·98	2·46	0·58	1·45	1·22	1·40
Starch and sugar ..	52·91	60·98	56·07	62·45	56·21	61·10
Cellulose	2·46	4·62	2·96	3·56	2·90	5·52
Ash	2·38	4·20	1·99	2·66	2·26	3·50

The garden pea (*Pisum sativum*) is eaten either fresh (green peas) or dried. Green peas cooked in the usual way contain from 12 to

[1] *Compt. Rend.*, cxxv. 119.

16 per cent. of carbohydrate, of which a considerable proportion is sugar. Of **beans** there are several edible varieties. The French or kidney bean (*Phaseolus vulgaris*) is eaten either in the young state along with the pod (haricots verts), or the seeds are consumed alone either fresh or after drying (haricots blancs). The amount of cellulose in the pod causes it to be digested and absorbed with difficulty, and on that account it is a wasteful form of food. Allied to the French bean is the scarlet runner (*Phaseolus multiflorus*), which when stewed constitutes 'Turkish beans.' The **broad** or **Windsor bean** (*Faba vulgaris*) is eaten either in the fresh or dry state. A coarser variety of the same plant is the horse or field bean. It is not usually consumed as human food.

Beans are on the whole richer in proteid than peas, but contain also more sulphur, and are more apt to cause flatulence.

The **Lentil** (*Lens esculenta*) is even richer in proteid than either the pea or the bean, and, as a rule, the smaller varieties of it are richer in that constituent than the larger. Egyptian lentils are amongst the best. Lentils contain little sulphur, and are more digestible and less apt to cause flatulence than either peas or beans. The ash of the Egyptian lentil is particularly rich in iron.

The patent preparation known as **Revalenta Arabica** consists mainly of lentil flour. The following is the result of an analysis which I recently made of it:

REVALENTA ARABICA.

Moisture	9·1	per cent.
Proteid	22·0	"
Fat	1·5	"
Carbohydrates	65·2	"
Mineral matter	2·2	"

It is really poorer in nitrogen than pure lentil flour. The latter costs 2½d. per pound; Revalenta, 3s. 6d. It certainly in no way merits the very high claims sometimes advanced for it. A soup-plateful of Revalenta made from three moderately-heaped table-spoonfuls (60 grammes) yields thirty-six Calories less than a similar quantity of good porridge, but is slightly richer in proteid and mineral matter. In other words, it is rather more valuable as a tissue-builder than porridge, but is not so good as a source of heat or energy. It must be remembered, too, that it is considerably more expensive.

The **Soy Bean** (*Glycine soja*) is the richest of all the pulses in proteid, and has also a large amount of fat, but very little starch. For this reason it is of use as a bread substitute in diabetes, a flour

being prepared from it and made into loaves or biscuits. In China it is extensively eaten in the form of soy cheese, and as various sauces and pastes. It is also grown in Southern Europe.

The **Peanut** (*Arachis hypogæa*), although botanically one of the pulses, really resembles more closely the true nuts. Like these, it is rich in proteids and fat, and may be used as a diabetic food. It enters into the composition of the patent food known as 'Nutrose,' and after expression of the oil it forms cakes for cattle.

The **Butter Bean** is a pulse recently introduced from California. It is of high nutritive value and of pleasant flavour, and is usually eaten stewed or fried.

Roots and Tubers.

We have already seen that the chief bulk of the grain of cereals is to be regarded as a storehouse of nutriment for the use of the young plant. The roots and tubers, the consideration of which will occupy our attention in this section, may be in like manner regarded as reserves of nourishment for the use of the adult plant itself. During the prosperous days of spring and early summer the plant lays by of its superfluity against the certain adversity of autumn. The reserve nutriment so laid up is almost entirely in the form of carbohydrates—chiefly starch. Proteid and fat are scarcely represented at all. Hence it is obvious that in using the roots and tubers as foods we are tapping a supply of only one of our nutritive elements, and that fact must never be lost sight of in estimating the value of this class of vegetable foods.

It remains to be added that, of the small proportion of nitrogenous matter which these foods contain, only part, and that not infrequently a very small part, is present in the form of proteid. On the other hand, they are by no means destitute of mineral ingredients, mainly as salts of potash, and the presence of these confers upon the roots and tubers a greater value as articles of diet than they would otherwise be entitled to possess.

As far back as the year 1781, Letheby tells us, Sir Gilbert Blane, in his work on 'Diseases of the Fleet,' alluded to the beneficial action of the potato in scurvy; and the late Dr. Baly remarked, in his inquiries into the diseases of prisoners, that wherever potatoes were used scurvy was unknown.

Another general consideration which must be borne in mind is that the mere cooking of these foods robs them of a very large proportion of their mineral ingredients and of some of the nitrogenous matter in which they are already so deficient. For this

reason the water in which they are cooked should also be utilized as far as possible, or, which is preferable, they should be cooked by means of steam.

COMPOSITION OF ROOTS AND TUBERS.

	H_2O.	Proteid.	Carbo-hydrate.	Fat.	Fibre.	Ash.	Extrac-tives.
Potatoes	76·7	1·2	19·1	0·1	0·6	0·9	1·4
„ (boiled in skin)	73·8						
Carrots	85·7	0·5 (Albu-minoid N x 6·25)	10·1	0·3	1·5	0·9	1·0
„ (cooked) ..	93·4	0·53	3·39	0·17	1·8	0·14	
Turnips	90·3	0·9	5·0	0·15	1·8	0·8	1·1
„ (cooked) ..	97·25	0·32	0·65	0·06	1·2	0·32	
Radishes	90·8	1·4	4·6	0·1	—	0·7	
Beetroots	83·9	0·5	11·0 (10 per cent. of sugar)	0·1	3·0	0·9	1·0
„ (cooked) ..	94·8	0·44	2·83	0·06	1·3	0·3	
Parsnips	80·1	1·4	14·1	1·0	2·1	1·3	
„ (cooked) ..	97·28	0·22	1·46	0·29	0·72	0·12	
Artichokes	79·8	2·3	14·5	0·3	2·0	1·0	
„ (cooked) ..	91·6	1·8	4·6	0·08	0·9	0·61	
Onions	89·1	1·6	6·3	0·3	2·0	0·6	
Sweet potatoes ..	72·9	1·6	22·5	0·5	1·8	0·7	
Yams	79·6	2·2	15·3	0·5	0·9	1·5	

As regards the **digestibility** of these foods as a class, it may be said that it depends largely on the amount of cellulose which each happens to contain, but it is true of all of them that they are **only indifferently absorbed**, and are prone, by reason of their bulk, to derange the stomach and bowels if eaten in large quantity.

We may now pass to a detailed examination of the chief members of the group, beginning with the potato.

POTATOES.

It is now about 300 years[1] since the potato was introduced into this country, and since that time it has steadily increased in popular favour, until it may now be regarded as one of the most important of our staple articles of diet.

If one cuts a raw potato across with a sharp knife and looks at the cut surface, three distinct **layers** can easily be made out

[1] A full account of the history of the discovery of the potato will be found in Weyl's 'Handbuch der Hygiene,' iii. 257.

(Fig. 18). These are (1) the thin outer skin. This contains a poisonous substance (solanine), which is destroyed by cooking; but, owing to the presence of this poison, the water in which potatoes have been boiled cannot be used to form stock, and as young potatoes contain a particularly large amount of the poison they must be steeped before use. (2) A broader layer inside the skin called the 'fibro-vascular layer.' It contains a small amount of pigment, and turns green when exposed to the light, giving the potato an unpleasant taste. (3) The flesh of the potato, which makes up the rest of its bulk. On more careful inspection one can see that this is divided into a central core and an outer zone which surrounds it.

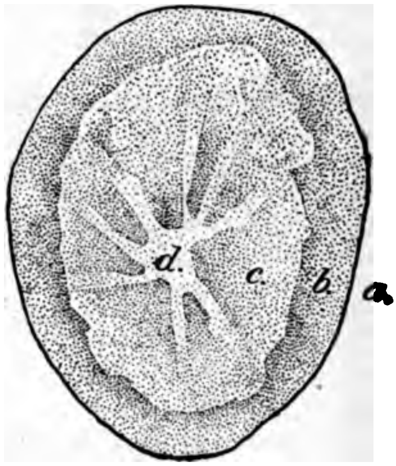

FIG. 18.—CROSS SECTION OF A POTATO
a, Skin; *b*, Fibro-vascular layer; *c*, Outer zone of flesh; *d*, Central core.

These different layers form the following proportions of the whole potato:

1. Outer rind	= 2½ per cent.
2. Fibro-vascular layer	= 8½ ,,
3. Flesh	= 89 ,,

The importance of recognising them is due to the fact that they differ considerably in chemical composition, as is shown in the following table:[1]

COMPOSITION OF A POTATO.

	Water.	Nitrogen. As Proteid.	Nitrogen. Total.	Fat.	Carbo-hydrate.	Mineral Matter.
Outer rind	80·1	0·25	0·43	0·8	14·6	1·8
Fibro-vascular layer	83·2	0·24	0·36	0·1	13·3	1·1
Flesh..	81·1	0·18	0·32	0·1	16·0	0·8
Whole potato ..	81·3	0·19	0·32	0·1	15·7	0·9

The fibro-vascular layer is seen to be considerably richer in mineral matter and proteid than the flesh, and in peeling it off with the rind we lose these valuable ingredients.

[1] See Bull. 43, United States Department of Agriculture, Office of Experiment Stations, Washington, 1897.

If the **flesh of the potato** is squeezed it can be separated into a **solid** part and a **juice**. The former consists mainly of starch; it has only 15 per cent. of the nitrogenous matter. The juice consists of water holding in solution nitrogenous matter and salts. It contains fully 85 per cent. of the total amount of nitrogenous matter contained in the potato.

It must be clearly realized that by no means all of this nitrogenous matter is present in the form of proteid. Of the total amount of nitrogen in a potato, only 49 per cent. is contained in proteids, the remainder being in the form of ammonia compounds (amides, *e.g.*, asparagin) and salts. The failure to recognise this fact has led people to assume that the whole of the nitrogen of the potato represents proteid, and so greatly to overrate the value of potatoes as tissue-building food.

The richer the potato is in proteid—in other words, the juicier it is—the more 'waxy' is it when cooked, for the coagulated proteid holds together. For this reason young potatoes, which contain more juice than those which are older and more starchy, have a more solid and waxy consistence when cooked than the latter.

The **richness of the potato in starch**, of which it contains from 18 to 19 per cent., is its most striking chemical characteristic, and causes it to be one of the chief commercial sources of that substance. Dextrin and 'British arrowroot' and many other things are prepared from it. The starch grain of the potato is of specially large size, and seems to be more easily attacked by ferments than most forms of starch, probably because it does not contain much 'starch cellulose.' This readiness to undergo fermentation causes potatoes to be foods which should be avoided in some diseased conditions, such as dilatation of the stomach.

The most important mineral ingredients of potatoes are salts of potash, and potatoes are one of the chief sources from which we obtain our supply of these salts. Part of the potash is united with citric acid. Potatoes, like all tubers, may have their composition, and consequently their nutritive value, profoundly modified by the **mode in which they are cooked**. The chief danger is that their nitrogenous constituents and mineral salts may be dissolved out. The amount of starch and water which they contain is scarcely ever affected.[1] These facts are brought out in the following analyses:[2]

[1] See analyses of cooked potatoes by Katherine Williams, *Journ. of Chem. Soc.*, lxi. 226, 1892.

[2] United States Department of Agriculture, Office of Experiment Stations, Bull. 43, p. 30.

THE LOSS OF MATERIAL DURING THE PROCESS OF COOKING POTATOES.

	Dry Matter.	Nitrogen.			Carbo-hydrates.	Ash.
		Proteid.	Non-Proteid.	Total.		
Skins removed before Boiling.						
Water cold at beginning of test	Per cent. 3·7	Per cent. 4·3	Per cent. 12·9	Per cent. 8·3	Per cent. 2·5	Per cent. 17·0
Water hot at beginning of test	4·0	3·3	17·9	10·0	2·8	17·4
Average	3·9	3·8	15·4	9·2	2·7	17·2
Boiled with Skins on.						
Water cold at beginning of test	0·3	0·6	0·6	0·6	0·2	1·9
Water hot at beginning of test	0·3	0·4	1·7	1·0	0·1	1·2
Average	0·3	0·5	1·1	0·8	0·2	1·6

The kind of water in which they are soaked does not make any difference. It has been calculated that if a bushel of potatoes were peeled and soaked before being boiled the loss of nutrients would be nearly equivalent to the amount contained in 1 pound of beefsteak. It follows from this that potatoes should either be steamed or cooked in their 'jackets.'

The accompanying diagram shows the percentage composition of a potato, and the loss of nutrients which it sustains when cooked by the usual method.

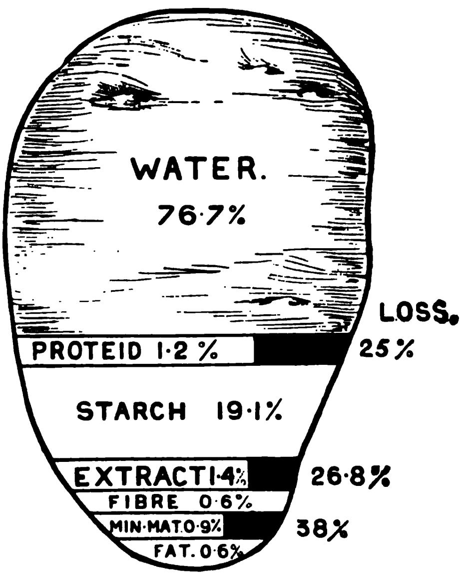

FIG. 19. — PERCENTAGE COMPOSITION OF A POTATO AND LOSS OF EACH CONSTITUENT ON BOILING.

The **digestibility of potatoes** in the mouth and stomach depends

largely on the form in which they are eaten. They are less digestible when eaten as lumps than in a purée; and 'mealy' potatoes are more digestible than 'waxy.'

Two medium-sized potatoes (weighing together 5⅓ ounces) when boiled and eaten in the usual way remain for about two to two and a half hours in the stomach—that is, a shorter time than a similar weight of bread.

In the intestine potatoes are, on the whole, **very well absorbed**. This is owing to the fact that they contain much starch and little cellulose. Even when the quantity consumed daily amounts to 3½ pounds, 92½ per cent. of the starch and 70 per cent. of the total nitrogen enters the blood.

Potatoes are, however, by no means suited to constitute the sole, or even the staple, diet of man. They are much too bulky, and contain too little proteid in proportion to their starch. Thus, it would require about 22 pounds of potatoes to yield even 118 grammes of proteid daily, while this quantity would contain more than four times as much carbohydrate as one really needs. As a matter of fact, however, Rubner has found that 6½ pounds of potatoes are enough to furnish 3,000 Calories of energy and to prevent any loss of bodily proteid. This is probably to be explained by the relatively enormous quantity of carbohydrates (*i.e.*, proteid-sparers) which such a diet contains.

An experiment mentioned by Pereira[1] illustrates this fact very well. In the year 1840 some experiments with a potato diet were made in a prison at Glasgow. Ten of the prisoners, consisting of young men and boys, were put on a diet of 6 pounds of potatoes daily. At the end of the experiment (the duration of which is not stated) the majority of the subjects had gained considerably in weight, and all expressed themselves as quite satisfied with the potatoes, and regretted the change back to ordinary fare. It must be added, however, that these prisoners were only engaged in light work, and the state of their nitrogen balance was not investigated.

Even granting that 6 pounds of potatoes per day is sufficient to supply fully all the needs of the body, it must be evident that this quantity is still unduly **bulky**, weighing as it does about twice as much as an ordinary mixed diet. The result of its continued use would be an undue burdening of the stomach and bowels, culminating in dilatation, if not disease, of these organs. The so-called 'potato belly' of the Irish peasant is an example of such a result.

It must also be borne in mind, in estimating the nutritive value of

[1] 'Food and Diet,' p. 372.

potatoes, that much of their nitrogen is in the form of substances which do not belong to the proteid group. Of these substances **asparagin**[1] is one of the chief. It contains 21·2 per cent. of nitrogen. Now, the direct nutritive value of asparagin is nil, but there is reason to believe that it plays a useful part in the intestine by limiting putrefaction, and so sparing proteids from destruction. It may also promote the absorption of proteids and carbohydrates into the blood. In the case of herbivorous animals these functions may be useful, but in carnivora and mixed feeders, which eat plenty of proteid, they are superfluous.[2]

As regards **economic value**, potatoes must be regarded as a cheap, but by no means the cheapest, kind of food. Thus, when potatoes are selling at 1d. and bread at 1½d per pound the former are two or three times dearer than the latter.[3] From the point of view of national economy, however, potatoes are undoubtedly a cheap food. Thus, Boussingault found that a given piece of land produces:

	Wheat.	*Rye.*	*Peas.*	*Potatoes.*
Proteid	510	440	560	950
Starch	1,590	1,196	780	6,840
Ash	90	62	60	323

Allied to the potato, though not now eaten in this country, are the sweet potato and the yam.

The **Sweet Potato** (batatas) is cultivated in hot countries, and is largely eaten in the United States. It used to be eaten in England before the present potato was introduced, and it is to it that Shakespeare refers when he makes Falstaff say, 'Let the sky rain potatoes!'

The **Yam** is the tuber of a tropical climbing plant and is much larger than the potato, but resembles it in taste.

The composition of the sweet potato and yam is represented in the table on p. 228. They are fully equal to the ordinary potato in nutritive value.

THE TURNIP.

The chemical composition of a **turnip** is graphically represented in Fig. 20. It is difficult to realize that an apparently solid object like a turnip really contains more water than a fluid like milk; yet such is the fact. A turnip contains almost no proteid, most of its nitrogen being in a non-albuminoid form. Carbohydrates are more abundantly represented than any other nutritive ingredient, but even they only amount to 5 per cent. Curiously enough, none of this is in the form

[1] Asparagin = amido-succinamic acid.
[2] See Kellner, *Maly's Jahres-Bericht*, p. 721, 1897, and Gabriel, *Zeit. f. Biolog.*, Bd. 29, p. 115, 1892; also König, 'Nahrungsmittel Chemie,' Bd. 1, p. 119.
[3] Smith, 'Foods,' p. 200.

of starch, that substance being left out in the turnip's composition. 'Pectose' bodies make up the bulk of the carbohydrate present. The nutritive value of these has already been discussed (p. 158). Seeing that starch and sugar are absent, there seems to be no reason why turnips should be forbidden to diabetics.

A consideration of the above facts shows that the turnip can never be regarded as an important form of food, a conclusion which is

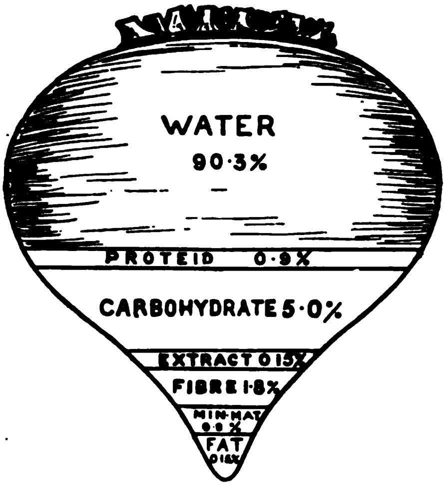

FIG. 20.—PERCENTAGE COMPOSITION OF A TURNIP.

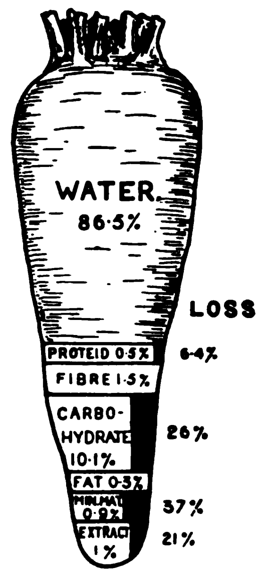

FIG. 21.—PERCENTAGE COMPOSITION OF A CARROT, AND LOSS OF EACH NUTRITIVE CONSTITUENT BY BOILING.

accentuated by the fact that the white turnip eaten at the table, though finer in flavour, is of even less nutritive value than the coarser 'swede.'

Carrots are decidedly more nutritious than turnips, mainly owing to their richness in sugar, of which they contain nearly 10 per cent. either as cane or fruit sugar. The amount of proteid which they possess is a negligible quantity, but their mineral salts are of some value. The composition of a carrot, and the loss of nutrients which it sustains on boiling, are represented in Fig. 21.

It has been found[1] that the following is the **loss of nutrients from the intestine on a diet of carrots and fat:**

[1] Rubner, *Zeit. f. Biolog.*, xv. 115, 1879.

Total solids lost	= 20·7	per cent
„ nitrogen lost	= 39·0	„
„ carbohydrates lost	= 18·2	„
„ mineral constituents	= 33·8	„

Carrots cannot, therefore, be regarded as at all a digestible form of food. Nor are they easily disposed of by the stomach, for 5¼ ounces remain there for three hours and twenty minutes.

Compared with the turnip and carrot, a raw **Beetroot** is a comparatively valuable source of food. Here, again, this is owing to the fact that it contains a large amount of cane-sugar. The ordinary garden beet contains nearly as much sugar as the 'sugar beet,' and by special cultivation the latter can be made to contain 15 per cent. of cane-sugar. In the process of cooking, however, much sugar is lost, so that ordinary beetroot as it comes to the table does not contain more than 3 per cent.

Like the carrot and turnip, the beetroot is of almost no value as a source of proteid. It contains altogether less than 2 per cent. of nitrogenous matter, and even of this only a fraction is in a proteid form. The exact proportions are:

35 per cent. of total nitrogen ..	= proteid.
39 „ „ „ ..	= amides.
36 „ „ „ ..	= ammonia salts and nitrates.

The beetroot is also richer in cellulose than most tubers. The addition of vinegar to slices of beetroot helps to soften the latter, while it does not interfere with the digestion of the other carbohydrates, seeing that these are already in the form of sugar.

Parsnips belong to the same order as the carrot. In the raw state they are fairly rich in starch and sugar, but lose much of the latter in the process of cooking.

Jerusalem artichokes resemble turnips in containing no starch, but are fairly rich in carbohydrates belonging to the gummy series, which make them very mucilaginous when boiled. They also contain a little sugar and about 2 per cent. of the peculiar carbohydrate **inulin**, the nutritive value of which is unknown. It is certainly better borne by diabetics than other forms of carbohydrate, and may be allowed in mild cases (Von Noorden). About half of the nitrogen artichokes contain is in a non-proteid form.

Onions are chiefly valued for their pungent oil, which makes them useful flavouring agents. They are thus to be regarded as condiments rather than foods. The large Spanish onion, however, is richer in nutrients, and may rank as a food. Onions are valuable in cases of constipation, probably owing to their richness in cellulose.

Tapioca, Sago and Arrowroot.

These are to be regarded simply as special forms of starch.

Tapioca is derived from the roots of South American cassava plants belonging to the Spurge order (Euphorbiaceæ). Curiously enough, one of these — the bitter cassava (*Manihot utilissima*) — contains, mixed up with the starch, a milky juice in which is present a good deal of that dangerous poison prussic acid. In preparing tapioca the juice is washed away from the grated root and the starch allowed to settle. It is then collected and dried on hot metal plates. The process of drying has the effect of rupturing most of the starch grains. Tapioca as found in the market contains about 11½ per cent. of water and 87½ per cent. of starch, along with traces of proteid and mineral matter, and has a fuel value of 1,650 Calories per pound. Pure starch contains only 2 per cent. of water, and a pound of it furnishes 1,825 Calories, so that weight for weight pure starch is considerably more nourishing than tapioca.

Tapioca remains a considerable time in the stomach. Forty grammes of it in the form of a thick gruel (about a soup-plateful) had not entirely left the stomach until after the lapse of two hours and forty minutes (Penzoldt). Its use should, therefore, be avoided in cases in which it is desirable to lighten the labours of the stomach.

Experiments upon the absorption of tapioca in the intestine have not been performed, but consisting as it does of starch alone, one would expect it to be absorbed very completely.

Sago is derived from the pith of the sago palm. The trees are felled, split, and the starch washed out. It is then dried, and converted into pearl sago by granulating. One tree should yield about 500 pounds of sago. Commercial sago contains 86·7 per cent. of starch.

Arrowroot is obtained from the rhizome of a West Indian plant (*Maranta arundinacea*). The roots are mashed up, mixed with water, and the starch allowed to settle. When dried, it constitutes ordinary arrowroot. The superiority of **Bermuda arrowroot** to the other varieties is due to greater care in manufacture. The starch, having been washed away from the mashed roots and strained through muslin, is allowed to settle, and is subsequently dried in flat copper pans covered with gauze. When dry, it is packed by means of German-silver shovels into new barrels lined with paper stuck in with arrowroot paste. All these precautions are necessary to prevent the arrowroot from becoming contaminated, as it is so apt to be, by foreign flavours. For a similar reason it is exported on deck under

covers, lest it may be affected by effluvia from the cargo in the hold.

Arrowroot contains 16½ per cent. of water, and 82½ per cent. of starch, along with only about 0·8 per cent. of proteid and 0·2 per cent. of mineral matter.

Tous les Mois resembles arrowroot very closely. It is derived from the root of *Canna edulis*, a West Indian plant. It has an extraordinarily large starch grain—the largest known, indeed; but apparently it is poor in starch cellulose, for it is very easily digested, and makes excellent blancmange.

Salep is a starchy preparation derived from the roots of various species of orchis, and imported into England from Smyrna.

The **digestibility of arrowroot** and its allies in the stomach is probably much the same as in the case of tapioca, and their absorption in the intestine is exceedingly complete. This gives them a special value in the treatment of diarrhœa.

As regards the **nutritive value** of all these preparations, it must be remembered that they are simply agreeable forms of starch; in other words, they consist almost entirely of carbohydrate, and should therefore not be eaten alone, but along with substances rich in proteid and fat. Eggs and milk are typical examples of such substances, and accordingly one finds that people have made puddings of tapioca, sago, or arrowroot along with milk and eggs before anything was known of the chemical constituents of the diet. **Tapioca pudding** has something like the following composition:

Water	61·8 per cent
Proteid	3·6 "
Fat	3·7 "
Carbohydrates	30·0 "
Mineral matters	0·9 "

and has a fuel value of about 780 Calories per pound (Atwater). It must be regarded as a highly nutritious food.

A cupful of **water-arrowroot** contains only about 30 grains of starch. It would furnish to the body about 9 Calories of fuel value, while even an invalid requires about 2,000 Calories daily.

When one considers the **economy** of these different preparations, one may say that tapioca and sago are worth the price paid for them, while the better qualities of arrowroot certainly are not. Starch at 4d. a pound is really rather dearer than tapioca at 3d. or sago at 2d., even although it contains 10 per cent. more nutriment. Apart altogether from that also, one cannot eat pure starch, whereas the same chemical substance in the form of tapioca or sago is quite

agreeable. On the other hand, Bermuda arrowroot at 2s. 9d., or even 1s. 6d., the pound is a purely luxurious article. The cheaper kinds at 4d. to 5½d. are quite as nutritious, and there can be no physiological objection to the substitution for the genuine article of the so-called **Farina** or **English arrowroot**, prepared from the starch of maize or potatoes, at 3d. per pound. Even although it requires more of these to make a jelly than of the genuine arrowroot, yet this difference is far more than made up for by the difference in price.

CHAPTER XIV

VEGETABLES—FRUITS—NUTS—FUNGI—ALGÆ AND LICHENS

Vegetables.

THE leaves of **green vegetables** are to be regarded as the lungs of the plant to which they belong. They are merely a sort of framework on which the green colouring matter,[1] by which the plant feeds and breathes, is spread out. They are in no sense, as the roots are, storehouses of reserve nutriment. One would not, therefore, expect that such leaves would have high nutritive value, and chemical analysis entirely confirms the expectation. Speaking generally, it may be said that green vegetables contain a great deal of water, almost no nitrogenous matter[2] or fat, and only a small quantity of carbohydrates (2 to 8 per cent.). This small proportion of carbohydrates renders their use, especially as carriers of fat, admissible in diabetes. Their framework contains a good deal of cellulose. The amount of mineral matter which they contain is relatively large, and confers upon them much of what value they possess as foods.

COMPOSITION OF VEGETABLES.

	Water.	Nitrogenous Matter.[3]	Fat.	Carbohydrates.	Mineral Matter.	Cellulose.	Fuel Value per lb.
							Calories.
Cabbage	89·6	1·8	0·4	5·8	1·3	1·1	165
,, (cooked)	97·4	0·6	0·1	0·4	0·13	1·3	
Cauliflower (head)	90·7	2·2	0·4	4·7	0·8	1·2	175
Sea-kale	93·3	1·4	—	3·8	0·6	0·9	
,, (cooked) ..	97·95	0·4	0·07	0·3	0·2	1·1	
Spinach	90·6	2·5	0·5	3·8	1·7	0·9	120

[1] Chlorophyll itself is of no nutritive value, but leaves the body hardly changed.
[2] Even of what nitrogenous matter is present only about half is in the form of proteid.
[3] Probably only about half of the nitrogenous matter consists of proteid.

COMPOSITION OF VEGETABLES—*continued.*

	Water.	Nitrogenous Matter.[1]	Fat.	Carbohydrates.	Mineral Matter.	Cellulose.	Fuel Value per lb.
							Calories.
Vegetable marrow	94·8	·06	0·2	2·6	0·5	1·3	
Vegetable marrow (cooked)	99·17	0·09	0·04	0·2	0·05	0·37	
Brussels sprouts ..	93·7	1·5	0·1	3·4	1·3	—	95
Tomatoes	91·9	1·3	0·2	5·0	0·7	1·1	105
„ (cooked)	94·07	1·0	0·2	0·1	0·76	1·5	
Greens	82·9	3·8	0·9	8·9	3·5	—	275
Lettuce	94·1	1·4	0·4	2·6	1·0	0·5	105
„ (cooked) ..	97·2	0·5	0·16	0·5	0·4	0·9	
Leeks	91·8	1·2	0·5	5·8	0·7	—	150
Celery	93·4	1·4	0·1	3·3	0·9	0·9	85
„ (cooked) ..	97·0	0·3	0·06	0·8	0·5	1·0	
Turnip cabbage ..	87·1	2·6	0·2	7·1	1·5	1·3	145
Rhubarb	94·6	0·7	0·7	2·3	0·6	1·1	105
Macedoine (tinned)	93·1	1·4	—	4·5	1·0	—	110
Watercress ..	93·1	0·7	0·5	3·7	1·3	0·7	
Cucumber	95·9	0·8	0·1	2·1	0·4	0·5	70
„ (cooked)	97·4	0·5	0·02	0·7	0·2	0·9	
Asparagus	91·7	2·2	0·2	2·9	0·9	2·1	110
Salsify (cooked) ..	87·2	1·2	0·08	9·0	0·3	2·2	
Endives	94·0	1·0	—	3·0	0·8	0·6	
Savoys	87·0	3·3	0·7	6·0	1·6	1·2	
Red cabbage ..	90·0	1·8	0·19	5·8	0·7	1·2	
Sauerkraut	91·0	1·4	0·7	2·8	1·7	0·9 (acids 1·26)	

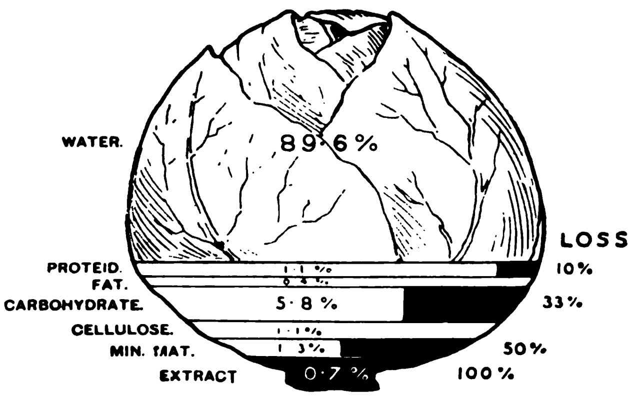

FIG. 22.—PERCENTAGE COMPOSITION OF A CABBAGE, AND LOSS OF EACH CONSTITUENT ON BOILING.

These facts regarding the composition of green vegetables will be better realized by a study of Figs. 22 and 23. The former represents the composition of a cabbage, *i.e.*, a typical green vegetable, while

[1] Probably only about half of the nitrogenous matter consists of proteid.

the latter depicts the ingredients of a cucumber, which is a type of one of the least nutritive of this class of foods.

The **effect of cooking** upon green vegetables is still further to reduce their already poor stock of nutrients. They gain water, and lose part of their carbohydrate and proteid, much of their mineral

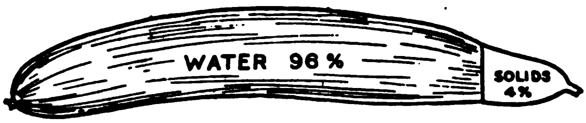

FIG. 23.—PERCENTAGE COMPOSITION OF A CUCUMBER.

matter, and nearly the whole of their non-albuminoid nitrogenous constituents. For example, a cabbage loses by boiling 30 per cent. of its total solids, this being made up of about half of the total mineral matter, one-third of the carbohydrate, the whole of the non-proteid nitrogen, and 5 to 10 per cent. of the proteid (see Fig. 22).

The **amount of water gained** by some of the commoner vegetables as the result of cooking is shown in the following table:[1]

GAIN OF WATER ON COOKING VEGETABLES.

	Percent. of Water in Raw State.	Percent. of Water after Cooking.	Increase.
Parsnips	82·0	97·2	15·2
Artichokes	80·0	91·6	11·6
Cabbage	89·0	97·5	8·5
Spinach	90·0	98·0	8·0
Cauliflower	90·8	96·4	5·6
Sea-kale	93·3	97·9	4·6
Vegetable marrow	94·8	99·1	4·3
Tomatoes	89·8	94·0	4·2
Celery	93·3	97·0	3·7
Lettuce	96·0	97·2	1·2
Cucumber	96·2	97·4	1·2

The next table shows the **amount of carbohydrate** contained in some of the commoner vegetables, and (in some cases) the loss on boiling:[2]

	Raw (*per cent.*).	*After Boiling and Straining* (*per cent.*).
Cabbage turnip (young)	3·09	2·43
Cauliflower	2·10	1·40
Spinach	2·97	0·85
Winter cabbage	6·75	3·20
Asparagus	—	1·6
Savoys	2·7	—

[1] From analyses by Katherine J. Williams, *Journ. of Chem. Soc.*, lxi. 226, 1892.
[2] From analyses by Kraus, *Zeit. f. Diät. und Physik. Therap.*, i. 69, 1898.

The **deficiency of fat in vegetables** is often made up by the addition of butter, etc., in the course of preparation for the table. Vegetables may thus be made an important vehicle for conveying fat into the body. The proportion of fat which some vegetables can take up without being overloaded is as follows :[1]

100 parts of	potato purée	can take up ..	.. 50	parts of fat.
" "	boiled potato	" " ..	.. 40-50	"
" "	baked ..	" " ..	.. ..	"
" "	red cabbage	" " ..	.. 40	"
" "	savoy cabbage	" " ..	.. 32	"
" "	cabbage lettuce	" " ..	.. 24	"
" "	potato soufflé	" " ..	.. 20	"
" "	fried potatoes	" " ..	.. 15	"

Vegetables, as a whole, are **not easily digested** by the stomach. Five and one-third ounces of cabbage require three hours. Cauliflower, it is worth knowing, is much the most easily digested of all of them. Five and one-third ounces of it require only two and a quarter hours.

In the intestine also vegetables are difficult to deal with. The reason for this is their bulk and the amount of cellulose which they contain. Gases are produced by the action of organisms on the cellulose, and from this flatulence is apt to result. Fermentation is specially apt to occur when the vegetables are a little stale. To be wholesome they should always be eaten as fresh as possible.

The **absorption** of the nutritive constituents of most vegetables is also rather defective. They constitute one of the few forms of food from which even starch is not completely absorbed. The average waste on green vegetables is approximately as follows (Rubner):

Dry substance	15·0 per cent. lost
Proteid	18·0 " "
Carbohydrates	15·4 " "
Mineral constituents	22·8 " "

When one realizes that green vegetables are poor in nutrients to start with, that they become still poorer as the result of cooking, and that even of the remnant which reaches the intestine a large part escapes absorption, one will readily understand that, considered as foods, they are of **very low nutritive value.** Indeed, it may be said that green vegetables are only of use in the diet for two reasons. Firstly, they supply **ballast** to the intestine; the indigestible residue which they leave is a stimulus to the intestinal movements. Hence their special value in constipation. Secondly, they are a **valuable**

[1] From analyses by Kraus, *Zeit. f. Diät. und Physik. Therap.*, i. 69, 1898.

source of mineral salts. The most abundant of these are compounds of potash, which have an alkaline reaction, and help to keep the blood supplied with alkali and to lower the acidity of the urine. It is probably owing to their richness in alkaline salts that the use of green vegetables is helpful in some diseases of the skin. Thus, Clement Dukes points out that he has several times seen epidemics of eczema result from a deficiency of green vegetables in the diet ('School Diet,' p. 103). For the same reason the free use of green vegetables should be recommended to patients who suffer from gravel. Their value in scurvy has long been known, cabbage being a most valuable antiscorbutic, and serviceable also in minor forms of scurvy, such as purpura and bleeding from the gums. Some vegetables, such as rhubarb, contain a good deal of oxalic acid. These should be avoided in cases of gravel. The sour taste of tomatoes is due to citric acid, not to oxalic, as is often stated. Green vegetables do not contain much iron, for that element, if present at all in the green colouring matter, is merely there in traces. The value of the mineral ingredients of vegetables will be dealt with more fully in a subsequent chapter.

Fruits.

The fruit is not of direct benefit to the plant. It is intended as a bait to attract birds or insects, and so insure the liberation or transportation of the seed. Hence the æsthetic qualities pre-

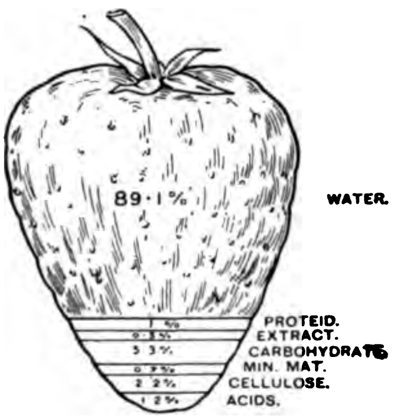

FIG. 24.—PERCENTAGE COMPOSITION OF A STRAWBERRY.

dominate in fruit rather than the strictly nutritive, and we eat them more for the sake of their sweetness and flavour than for the actual nourishment which they afford.

16—2

The general composition of fresh fruit is something like this:

Water	85 to 90 per cent.
Proteid	0·5 ,,
Fat	0·5 ,,
Carbohydrates	5½ to 10½ ,,
Cellulose	2½ ,,
Mineral matters	0·5 ,,

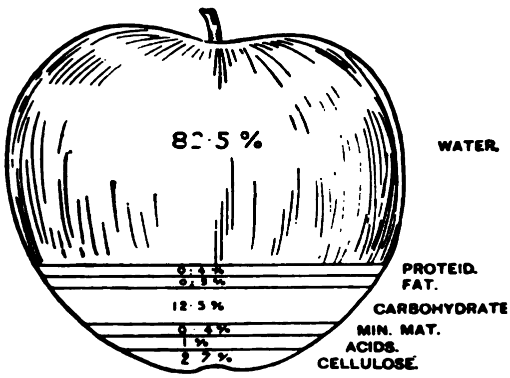

FIG. 25.—PERCENTAGE COMPOSITION OF AN APPLE.

The composition of individual members of the group is shown in the following table. A study of the graphic representation of some typical fruits will illustrate the table (Figs. 24, 25 and 26).

COMPOSITION OF FRUITS.

	Water.	Proteid.	Ether Extract.	Carbo-hydrates.	Ash.	Cellu-lose.	Acids.
Apples	82·5	0·4	0·5	12·5	0·4	2·7	1·0
,, (dried) ..	36·2	1·4	3·0	49·1	1·8	4)	3·6
Pears	83·9	0·4	0·6	11·5	0·4	3 1	0·1
Apricots	85·0	1·1	?	12·4	0·5		1·0
Peaches	88·8	0·5	0·2	5·8	0·6	3 1	0·7
Greengages ..	80·8	0·4	—	13·4	0·3	4 1	1·0
Plums	78·4	1·0	?	14·8	0·5	4 3	1·0
Nectarines	82·9	0·6	?	15·9	0·6		
Cherries	84·0	0·8	0·8	10·0	0·6	3 8	1·0 to 1·5 (Stutzer)
Gooseberries ..	86·0	0·4	—	8·9	0·5	2·7	1·5
Currants (red, black and white) ..	85·2	0·4	—	7·9	0·5	4·6	1·4
Strawberries ..	89·1	1·0	0·5	6·3	0·7	2·2	1·0 to 1·2
Whortleberries (= Blaeberries or Bilberries)	76·3	0·7	3·0	5·8	0·4	12·2	1·6
Blackberries ..	88·9	0·9	2·1	2·3	0·6	5·2	
Raspberries ..	84·4	1·0	?	5·2	0·6	7·4	1·4
Cranberries ..	86·5	0·5	0·7	3·9	0·2	6·2	2·0 to 2·5
Mulberries	84·7	0·3	—	11·4	0·6	0·9	1·8

COMPOSITION OF FRUITS—*continued.*

	Water.	Proteid.	Ether Extract.	Carbo-hydrates.	Ash.	Cellu-lose.	Acids.
Grapes	79·0	1·0	1·0	15·5	0·5	2·5	0·5
Melons	89·8	0·7	0·3	7·6	0·6	1·0	
Water-melons ..	92·9	0·3	0·1	6·5	0·2		
Bananas	74·0	1·5	0·7	22·9	0·9	0·2	
Oranges	86·7	0·9	0·6	8·7	0·6	1·5	1·0 to 2·5
Orange-juice ..	85·0	—	—	10·8	—	—	1·93
Lemons	89·3	1·0	0·9	8·3	0·5		
Lemon-juice ..	90·0	—	—	2·0	0·4	—	7·0 (citric acid)
Pineapples	89·3	0·4	0·3	9·7	0·3		
Dates (dried) ..	20·8	4·4	2·1	65·7	1·5	5·5	
Figs (dried) ..	20·0	5·5	0·9	62·8	2·3	7·3	1·2
,, (fresh) ..	79·1	1·5	—	18·8	0·6		
Prunes (dried) ..	26·4	2·4	0·8	66·2	1·5	—	2·7
,, (fresh) ..	80·2	0·8	?	18·5	0·5		
Currants (dried) ..	27·9	1·2	3·0	64·0	2·2	1·7	
Raisins	14·0	2·5	4·7	74·7	4·1		

The composition of edible parts only is represented. Where cellulose is not given it is included with carbohydrates.

It will be observed that the only nutritive element of any importance in fruit is the **carbohydrate group**. As a general rule, about half to three-quarters of the total carbohydrates in a fruit will consist of sugar. The particular variety of sugar is that known as fruit-sugar, or, in chemical language, lævulose; but some fruits, *e.g.*, apples, apricots, and pineapples, contain a considerable amount of cane-sugar as well. It is of some importance to remember this, for lævulose is certainly more easily assimilated by diabetics than other sugars are, so that fruits may often be allowed to mild cases of that disease with impunity. The total amount of sugar contained in some typical fruits is shown in the following table:[1]

	Total Sugar (per cent.).
Hot-house grapes	17·26
Preserved ,, ...	16·5c
Figs	11·55
Cherries	10·00
Preserved pears	8·78
Fresh pears	7·84
White currants	6·40
Strawberries	5·86
Preserved apples	6·25
Raspberries	7·23
Oranges	8·58
Apricots	8·78
Pineapples	13·31
Plums	1·99
Lemons	1·47

[1] Analyses by Buignet (quoted by König).

The remainder of the carbohydrates is made up of vegetable gums. Many of these seem to belong to that group of 'pectin bodies' to which reference has already been made (p. 158). In the course of ripening, some of them seem to be converted into the corresponding sugar—**pentose**, the nutritive value of which must be regarded as very doubtful. When subjected to boiling, the gums of many fruits yield a jelly, the production of which is familiar in the process of making preserves.

The amount of **cellulose** varies greatly in different fruits. It is always lessened by the process of cultivation—witness the difference between a crab apple and a Newton pippin—and it diminishes also, by a sort of natural digestion, during the ripening of the fruit.

The **mineral constituents** of fruits are of considerable importance. They consist mainly of potash united with various vegetable acids, such as tartaric, citric, malic, etc. These have an agreeable acid flavour, but when burnt up inside the body are converted into the corresponding carbonate, and so help to render the blood more alkaline and the urine less acid. Thus, 1 fluid ounce of lemon-juice contains 45 grains of citric acid and saturates 45½ grains of bicarbonate of soda. In some diseases, such as scurvy, this property of the mineral constituents of fresh fruit is turned to therapeutic account. As the fruit ripens, these vegetable acids diminish to some extent, and it is to this fact, coupled with an increase in the amount of sugar present, that the sweetness of ripe as compared with unripe fruit is due. The earthy salts are but poorly represented among the mineral ingredients of fruits, and for this reason the free use of fruit in place of cereals has been recommended by some writers to persons suffering from atheroma.

The **odour and flavour of fruits** are due to the presence of very small quantities of ethereal bodies which sometimes elude chemical investigation. In many cases, however, we have been able to obtain (from coal-tar, too, of all sources) artificial products which have precisely the same flavour as many fruits. These products form the basis of the different fruit flavourings and essences sold in the shops. Although of no nutritive value, these flavouring substances contained in fruits are by no means to be despised as stimulants to the appetite and aids to digestion.

Cooking renders most fruits more digestible by softening their cellulose, and it also, as we have seen, converts the gums into a gelatinous form. But these changes are not brought about without **a good deal of loss**. The loss affects all the ingredients of the fruit.

The following instances show the exact figures for the carbohydrates:[1]

Raw apples ..	..	..	11·7 per cent.	carbohydrates
Apples once boiled	..	..	7·3 „	„
„ twice „	..	..	6·1 „	„
Raw pears ..	..	..	10·1 „	„
Pears once boiled	..	..	6·6 „	„
„ twice „	..	..	5·9 „	„
Raw peaches ..	..	..	9·5 „	„
Peaches once boiled	..	..	1·8 „	„

Where, as is usually the case, the fruit is cooked by stewing and the juice eaten along with it, this effect of cooking is of no moment.

The **digestibility of fruit** in the stomach and intestine is dependent largely on the nature of the fruit and its degree of ripeness. Five and a third ounces of raw ripe apple (one large or two small apples) requires about three hours and ten minutes for its digestion by the stomach. On the other hand, if the fruit be unripe and the amount of cellulose consequently greater, digestion may be much more prolonged. The excess of acids present in unripe fruit causes the latter to be irritating to the intestine, and a frequent originator of diarrhœa and colic. If, however, the cellulose and acids are contained in more moderate quantity, as in ripe fruit, the gentle stimulation which they exert on the intestinal wall may be very useful. Hence it is that stewed fruit is so serviceable an addition to the diet in sluggish action of the bowels.

There have been no experiments made to test the degree to which fruit is absorbed by the human intestine. One may reasonably expect it to correspond pretty closely with the absorption of fresh vegetables. In other words, the proteid will be absorbed to about 80 per cent., the fats to 90 per cent., and the carbohydrates to 95 per cent., if the conditions be reasonably favourable.

From a nutritive point of view fruits may be artificially diyided into the two groups of **flavour-fruits** and **food-fruits**. In the former one would include all fruits which contain more than 80 per cent. of water; in the latter, all fruits or fruit preparations which have more than 20 per cent. of solids.

The only claim of the members of the first group to be regarded as foods is that they contain a small amount of sugar in a pleasant but rather bulky form. They are chiefly eaten for the sake of their pleasant flavour. Their richness in water makes them more adapted to the requirements of the inhabitants of warm countries than for use in northerly latitudes, and one finds that if they are freely represented in the diet less water requires to be consumed.

[1] From analyses by Kraus, *Zeit. f. Diät. u. Physik. Therap.*, i. 69, 1898.

Grapes stand intermediate between the two groups, for their juice contains an amount of sugar which varies from 10 per cent. in the poorer up to 30 per cent. in the richer varieties. In the so-called **grape-cure**, from 1 to 8 pounds of grapes are taken daily in divided quantities, and between meals. If the rest of the diet is sufficient, the patient may gain weight on this regimen, while the grape-juice, owing mainly to the organic acids which it contains, acts as a mild laxative and diuretic, and at the same time diminishes slightly the acidity of the urine. In this, as in all similar 'treatments,' much of the credit of the results attained must be put down to the circumstances under which the 'cure' is carried out, for the patient is expected to gather the grapes for himself, and doing this entails a certain amount of exercise in the fresh air. It is chiefly in cases of so-called 'abdominal plethora,' *i.e.*, the results of habitually eating too much and exercising too little, that benefit has been observed from such a course of treatment.

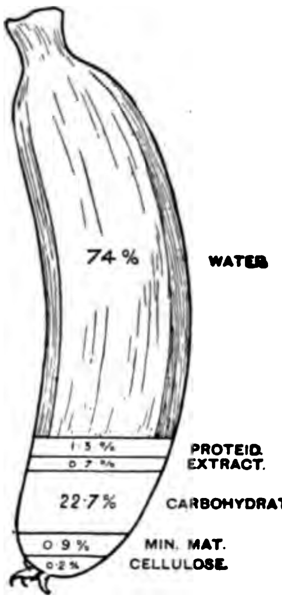

FIG. 26.—PERCENTAGE COMPOSITION OF A BANANA.

The **food-fruits**, on the other hand, are not to be despised as sources of real nutriment. Of this group the **banana** is a good example. In the fresh state this fruit contains a fair amount of carbohydrate and an appreciable amount of proteid as well, while bananas dried in the sun and sprinkled with sugar, a form in which they have recently been imported, compare favourably with dried figs in nutritive value, and are a pleasant substitute for the latter at dessert.

In its ordinary form, however, the banana is too bulky to be able to serve as the main constituent of a healthy diet. Assuming that an average sized specimen weighs 45 grammes (without the husk), it would require about eighty of these to yield the amount of energy required daily, and nearly double that number to supply the requisite amount of proteid. No wonder, then, that in tropical countries, where the banana is largely eaten, the inhabitants are apt to show an undue abdominal development.

The unripe banana is dried and used to produce **banana meal or flour**. A sample of such a flour had the following composition:

	Banana Flour.	Wheat Flour.
Moisture	13·0 per cent.	13·8 per cent.
Proteid	4·0 ,,	7·9 ,,
Fat	0·5 ,,	1·4 ,,
Carbohydrates	80·0 ,,	76·4 ,,
Mineral matter	2·5 ,,	0·5 ,,

I have placed alongside it the composition of good wheat flour, compared with which the banana-meal is rich in carbohydrates and mineral matter, but very poor in proteid. If rice, on the other hand, had been taken for comparison, it would have been found that banana flour was about equal to it in nutritive value.

Banana flour can be used to make a sort of bread, and it is said to be easy of digestion. Two pounds of such flour and a quarter of a pound of salt meat or fish is stated to form the daily allowance for a labourer in tropical America (Johnston).

Another advantage of the banana is the cheapness with which it can be produced. A given area of ground devoted to its cultivation will yield a larger food return than in any other form, unless it be planted with chestnut-trees.

'A spot of a little more than 1,000 square feet will contain from thirty to forty banana plants. A cluster of bananas produced on a single plant often contains from 160 to 180 fruits, and weighs from 70 to 80 pounds. But reckoning the weight of a cluster only at 40 pounds, such a plantation would produce more than 4,000 pounds of nutritive substance. M. Humboldt calculates that as 33 pounds of wheat and 99 pounds of potatoes require the same space as that in which 4,000 pounds of bananas are grown, the produce of bananas is consequently to that of wheat as 133 : 1, and to that of potatoes as 44 : 1. . . . A much greater number of individuals may be supported on the produce of a piece of ground planted with bananas, compared with a piece the same size in Europe growing wheat. Humboldt estimates the proportion as 25 to 1; and he illustrates the fact by remarking that a European, newly arrived in the torrid zone, is struck with nothing so much as the smallness of the spots under cultivation round a cabin which contains a numerous family of Indians' (Knight).

It is evident from this that we possess in the banana a potential source of cheap nourishment which may one day be of great importance.

Surpassing even the banana in nutritive value is the group of **dried fruits**, which includes such examples as the **date** and the **raisin**. The former, indeed, is as much a staple article of diet to the Egyptian as rice is to the Hindu, but the carbohydrate of rice

is mainly in the form of starch, whereas in the date it is almost solely present as sugar. 'A half-pound of dates and half a pint of milk makes an ample and satisfying meal for a person engaged in sedentary labour' (Densmore).

The **fig** is another valuable member of this group. Weight for weight, dried figs are more nourishing than bread, and a pint of milk and 6 ounces of dried figs makes a good meal. One and a half pounds of them yield 400 grammes of carbohydrate, or four-fifths of the total amount of that nutritive ingredient required daily.

Nuts.

Nuts differ very markedly from the fruits which we have been considering, in that they are of very high nutritive value. Bulk for bulk, indeed, dry nuts are amongst the most nutritive foods which we possess. Their **general composition** is roughly as follows:

Water	4 to 5 per cent.
Proteid	15 ,, 20 ,,
Fat	50 ,, 60 ,,
Carbohydrates	9 ,, 12 ,,
Cellulose	3 ,, 5 ,,
Mineral matter	1 per cent.

A graphic representation of a typical specimen of the group, the walnut, is shown in Fig. 27.

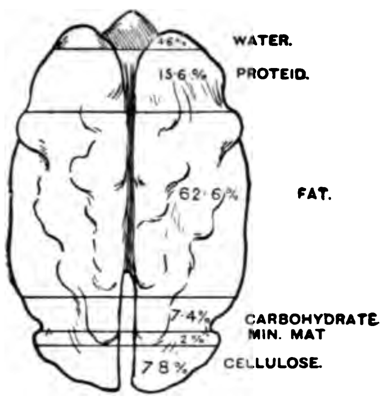

FIG. 27.—PERCENTAGE COMPOSITION OF A WALNUT.

It will be observed that fatty matter predominates very largely in the composition of nuts. No other vegetable substance is so rich in fats as these. Advantage has been taken of this to prepare from nuts various fatty preparations which are used as cheap and efficient **substitutes for ordinary butter** in the kitchen. Amongst these are the commercial preparations known as 'Albene,'[1] 'Nucoline'[1] 'Vegsu,' or vegetable suet,'[2] 'Nut Butter' and 'Nuttolene,'[3] also 'Cocos Butter,' 'Cocoleum,' and 'Cocolardo.'[4] There is every reason to believe that these are

[1] Prepared by Broomfield and Co., 83, Upper Thames Street, E.C.

[2] 'Loders and Nucoline,' Lim., Silvertown, E. This firm also prepare 'Nucoa' and 'Loders' Cacos' as substitutes for cocoa butter.

[3] Manufactured by the Nut Food Co., Battle Creek, Michigan, U.S.A. (the London Food Co., 451, Holloway Road, N.).

[4] East Indian Products Co., Lim., 7, East Indian Avenue, London, E.C.

equal in nutritive value to ordinary butter, whilst they are decidedly more economical. 'Albene' costs 9d. per pound, and 10 ounces of it are said to go as far as 1 pound of butter. 'Nucoline' costs 6d. per pound, and 4 pounds of it are stated to be equivalent in cooking operations to 6 pounds of butter. 'Nut Butter' and 'Nuttolene' contain proteid as well as fat, and are therefore to be compared to cream rather than to ordinary butter.

Unfortunately, nuts are **not readily digested** in the stomach. This is due in part to their richness in fat, and partly also to their containing a high proportion of cellulose, which forms a dense and compact framework throughout the structure of the nut. By thorough mastication, the latter difficulty can be overcome to some extent, but it is still more efficiently dealt with by artificial grinding and cooking. Various preparations derived from nuts, in which this mechanical cause of difficulty in their digestion has been to a large extent overcome, are now in the market. Best known of these are the 'Fromm's Extract,' and the various preparations of the Sanitas Nut Food Co. ('Nuttose,' 'Bromose,' 'Nutmeal,' etc.).

Fromm's Extract consists of nuts which have been crushed, and from which the excess of cellulose and oil have been removed. The preparation is then cooked under special conditions, which develops in it a flavour not unlike that of meat. It has the following composition:

FROMM'S EXTRACT.

Water	25·3 per cent.
Proteids	21·9 „
Fat	31·6 „
Carbohydrates and cellulose	8·3 „
Mineral matter	12·8 „

There can be no doubt that this is a preparation of high nutritive value. It costs, however, 3s. 6d. per pound.

Unfortunately, no experiments have been made to test the degree to which the nutritive constituents of nuts are absorbed in the intestine. One would expect that the waste of proteid, at least, would be very considerable.

The **nutritive value of nuts** is no doubt extremely high, and when suitably prepared they may form substitutes for meat to a considerable extent, for they resemble the latter in containing much proteid and fat in small bulk. Thirty large walnuts (weighing, without the shells, 100 grammes) would contain as much fat as 2¼ pounds of moderately lean beef, but 2⅗ ounces of such beef would be equal to them in proteid. It would be necessary to consume about

700 walnuts in order to obtain the necessary amount of proteïd required by the body every day.

A cocoanut weighing 1¼ pounds contains ¼ pound of fat. Its price is about 2d., so that as a source of fat it is equivalent to butter at 8d. the pound.

Of all the members of this class of foods, the **chestnut** is probably of the greatest general value as an article of diet. This is due to its containing a high proportion of carbohydrates along with much proteid and fat, as is shown in the following recent analyses:

COMPOSITION OF CHESTNUTS.[1]

	H_2O.	N Matter.	Fat.	Carbo-hydrates.	Cellulose.	Ash.	Acidity.
Minimum Normal	52·80	2·01	0·45	31·54	0·74	0·57	0·059
Minimum Dried ..	0·00	4·45	1·17	82·17	1·76	1·24	0·164
Maximum Normal	62·60	4·31	1·73	40·74	1·36	1·22	
Maximum Dried ..	0·00	11·05	3·74	88·61	3·29	3·06	

Roasted chestnuts have 40 per cent. water. Those cooked by boiling have 72 per cent.

An economic point in favour of chestnuts also is the fact that a given area of ground produces the maximum amount of human food when planted with chestnut-trees.

The great value of the chestnut has been fully recognised by the poorer peasantry of Central France. During the autumn and winter they often make two meals from chestnuts each day. The nuts are prepared by removing the outside shell, blanching, and then steaming; salt and milk are added when they are eaten. Sometimes they are ground after blanching, and the meal made into flat cakes.

The **almond** is another very valuable form of nut, being specially noteworthy for the large amount of nitrogenous matter which it contains. It has the further advantage of being compact and portable. 'No man,' it has been said, 'need starve on a journey who can fill his waistcoat pocket with almonds' (Newman).

Owing to its poverty in carbohydrates, the almond is largely employed in the manufacture of diabetic breads. The detailed composition of the commoner varieties of nuts is exhibited in the following table:

[1] Balland, ref. *Analyst*, p. 216, 1897.

COMPOSITION OF NUTS.

	Water.	Proteid.	Fat.	Carbohydrates.	Cellulose.	Mineral Matter.
Chestnuts (fresh) ..	38·5	6·6	8·0	45·2		1·7
,, (dried) ..	5·8	10·1	10·0	71·4		2·7
Walnuts (fresh) ..	44·5	12·0	31·6	9·4	0·8	1·7
,, (dried) ..	4·6	15·6	62·6	7·4	7·8	2·0
Filberts and hazels (fresh)	48·0	8·0	28·5	11·5	2·5	1·5
Filberts and hazels (dried)	3·7	14·9	66·4	9·7	3·2	1·8
Sweet almonds ..	6·0	24·0	54·0	10·0	3·0	3·0
Pistachio kernels ..	7·4	21·7	51·1	14·0	2·5	3·3
Cocoanut (fleshy part)	46·6	5·2	35·9	8·4	2·9	1·0
Cocoanut (dried) ..	3·5	6·0	57·4	31·8		1·3
,, (milk) ..	90·3	0·5	—	9·0		

Fungi.

The edible fungi are popularly spoken of as **mushrooms**, and the inedible ones as **toadstools**. There is really, however, no such division, for all the larger fleshy fungi are toadstools, and probably most of them are edible. The word 'mushroom' has therefore only the practical convenience of distinguishing the best-known edible fungi met with in commerce.

There are about 1,400 species of toadstools met with in this country, and of these about a hundred are known to be edible, while not more than thirty have been definitely proved to be poisonous. There are probably a great many more edible varieties, but the only way of finding out whether they are so or not is by trying—a mode of experiment which is somewhat risky. But our ignorance in this respect need not be a matter of regret, for even although many more toadstools should be found to be harmless, yet they are probably not worth the eating.

The poisonous properties of fungi are due to the presence in them of alkaloids. The nature of these differs in the different species, so that the symptoms of toadstool-poisoning are varied. The genus *Amanita*, most of which are very dangerous, contains an alkaloid called amanitine, which acts as an irritant to the stomach and bowels, and also paralyzes the nervous system. This poison is peculiar in that it does not exert its effects for some hours after the fungus has been swallowed, so that at first the patient feels perfectly well. It is, however, extremely potent, so that a very small portion of such a fungus may prove fatal. The alkaloid found in the poisonous examples of *Russula* and *Lactarius* is purely irritant in its effects, and induces vomiting and diarrhœa, thus leading to the

discharge of the fungus, and bringing about its own cure. The symptoms, too, follow immediately upon the eating of the fungus, and without any delay. The *Agaricus muscarius* contains the alkaloid muscarin, which produces symptoms very much resembling those of cholera. The Czar Alexis lost his life by eating it.

It is not easy to lay down definite rules for the recognition of the harmless fungi, while, unfortunately, some of the most dangerous are also those of commonest growth. Certain general indications it is always safe to observe. Thus, all fungi should be avoided when they are overripe, or when they have been attacked by slugs. Those that soften easily are usually dangerous, and the same is true of fungi which grow in dirty situations, such as dunghills, for this kind of plant has a great tendency to absorb poisons from the medium on which it happens to be growing. Lastly, all those which have a disagreeable smell or taste should certainly be rejected.

The fungus-eater's safest ground is unquestionably amongst the *Boletus* family. The distinguishing mark of these fungi, as opposed to the *Agarici* is that they have tubes under the cap instead of gills Of the forty-nine native species of this family, most are edible, and many quite excellent. But there are exceptions, one or two members being virulently poisonous. There need not, however, be any difficulty in distinguishing these, for all the safe ones are characterized by being yellow beneath the cap. To this rule there is only one exception, and it is easily told by its scarlet stem. All those that are red or pink or orange or brown beneath the cap should be avoided. It is well also to discard all those which change colour on cutting or bruising.

The *Boletus edulis* occurs abundantly in beech woods, especially in the South of England. It has a light brown cap, the under part of which is first white and then yellow-green, with a thickish pale brown stem, surmounted by a fine white network. This network is the best feature by which to distinguish it from its congeners. It is in best edible condition when the under surface is yellowish.

Belonging to a different family (the Hydnei, or teeth-bearing fungi) is the *Hydnum repandum*—the urchin of the wood. It is of a buff white colour, and is easily recognised by the long unequal spines beneath its cap. It is amongst the most delicate of toadstools, having a slight flavour of oysters. It is best in the young and fresh state, and is largely employed as food in Belgium, Austria, and France. The Agaricus family includes a large number of edible fungi, the best known of which is the common mushroom (*Agaricus campestris*). Another favourite is the *Agaricus gambosus*, or St. George's mushroom, which is found in spring and early summer,

growing on downs and pastures, often in immense fairy-rings. Its stem is stout and solid, and the gills yellowish-white and much crowded together. It has a strong odour of fresh meal, which is so powerful that workmen employed to root out the fungus are said to have been so overcome by the odour as to be compelled to desist (Cook). It is better eating than the common mushroom.

One of the best of all is the *Paxillus giganteus*, which is found in August and September. It is firm in texture and of a dingy white colour with yellow stains on the stem. It is easily identified by its fine, creamy white gills and its broad inrolled disc.

The *Lactarius deliciosus* and the *Cantharellus Cibarius* (chantrelle) belong to different groups. The former, as its name implies, is one of the nicest of all edible fungi. It is not difficult to recognise, but is apt to be attacked by a reddish parasitic fungus, and in that state is dangerous. It is of an orange colour with a yellowish, milky juice, and grows abundantly in fir plantations. The chantrelle is found in large numbers in most of our woods in autumn. It is orange yellow both within and without, and has a pleasant smell of ripe apricots. It has a delightful flavour, and one writer goes the length of saying that if properly prepared 'it would arrest the pangs of death!'

The common morel (*Morchella esculenta*) and the truffle (*Tuber cibarium*) are both much-prized fungi. The former grows in England, but is usually imported from abroad in a dried state, and fetches a high price. The truffle is an underground fungus which grows in dry soils. In England it is chiefly found in Wiltshire, Hampshire, and Kent. The black variety is most esteemed. Both morels and truffles are chiefly valued for their delicate flavour, and are common constituents of seasonings and sauces. Though usually eaten dried, they are very much better when fresh.

The **chemical composition** of the commoner edible fungi is shown in the following table:

COMPOSITION OF FUNGI.[1]

	Mushroom (*Agaricus campestris*).	Chantrelle (*Cantharellus cibarius*).	Truffle (*Tuber cibarium*).	Edible Boletus (*Boletus edulis*).	*Lactarius deliciosus*.
Moisture	93·7	90·93	73·0	84·19	89·08
Amides, etc.	1·3	0·64	1·4	2·6	0·91
Proteids	2·2	1·19	6·1	3·7	1·88
Fat	0·3	0·64	0·6	0·4	0·54
Carbohydrates	1·2	5·09	60·2	4·65	4·49
Cellulose	1·1	0·33	6·4	0·74	0·32
Mineral matter	0·3	1·20	2·0		

[1] Chiefly compiled from analyses by Stahl-Schröder, *Maly's Jahres-Bericht*, p. 699, 1897. See also Lafayette B. Mendel, *American Journal of Physiology*, i. 225, 1898.

The following analysis of the solids and nitrogenous matter in tinned French mushrooms is given by Saltet:[1]

	Dry Substance.	Total Nitrogen.	Percentage of N in Dry Substance.	Proportion of the Total N present.
Mushrooms	37·84	2·7	7·13	84·9
Fluid in tin	8·91	0·48[2]	5·39	15·1
Together ..	46·75	3·18	6·8	100·0

It will be observed that as a class they contain but little dry substance. Of this, a comparatively large amount is nitrogenous matter, the remainder being chiefly made up of carbohydrates. The older fungi contain more nitrogen than the younger plants, and those which are cultivated are richer than those which grow wild. It must not, however, be supposed that the nitrogenous matter of the fungi is all in a form available for nutrition. On the contrary, a large proportion of it is in the form of **amides** and other non-proteid bodies. Indeed, a reference to the table will show that the actual amount of albuminoid matter which the fungi contain is, with the exception, perhaps, of truffles, by no means large at all.

It is probably to the amides and their allies that most of the peculiar flavour of the fungi is to be attributed.

Recent analyses[3] of the different forms of nitrogen present in some common fungi have yielded the following results:

	Cantharelus Cibarius.	*Boletus Edulis.*	*Lactarius Deliciosus.*	*Morchella Esculenta.*	*Agaricus Campestris.*
Total N	2·69	3·87	3·11	4·99	7·38
Proteid N	2·29	2·73	2·51	4·18	4·89
'Extractive' N	0·40	1·14	0·60	0·81	2·49
Indigestible proteid N	1·46	0·65	1·05	1·90	1·17
Digestible " ..	0·79	2·10	1·41	2·19	3·64

Starch is not represented amongst the carbohydrates of the fungi. They contain instead a curious and rare sugar called trehalose (mycose)[4] and a substance termed mannite, which is the parent of a sugar named mannose. The nutritive value of both of these substances is unknown. There is some reason to believe that mannite, at least, is not easily assimilated.[5] The fungi contain also a good

[1] *Archiv. f. Hygiene*, Bd. 3, p. 443, 1885.
[2] Probably mostly in form of amides.
[3] Mendel, *Amer. Journ. of Physiolog.*, i. 225, 1898.
[4] Winterstein, *Zeit. f. Physiolog. Chem.*, xxvi. 438, 1899.
[5] Jaffé, *Zeit. f. Physiolog. Chem.*, Bd. 7, p. 297, 1883.

deal of cellulose, which seems to differ somewhat from that found in most plants.

As a result of **cooking** fungi shrivel up considerably. This is due to coagulation of the contents of the cells, which shrink instead of bursting, as they probably would do if they contained starch. They lose, also, much of their non-albuminoid nitrogenous constituents, and with these much of their flavour. They also gain in water to some extent, so that a stewed mushroom contains only about 2 per cent. of solid matter.[1]

Fungi are **not easily digested** in the stomach. This is matter of common knowledge. The difficulty is probably largely due to the amount of cellulose which they contain, and to the shrinkage and greater compactness which result from cooking. The pain and discomfort which they are apt to produce in the stomach have often been wrongly attributed to poisons, and in consequence fungi which are merely indigestible have been regarded as inedible. Recent experiments *in vitro* have amply confirmed their indigestibility.[2]

The **absorption** of the fungi is also very imperfect. One observer[3] took large quantities of fresh mushrooms daily. He found that 19 per cent. of the dry substance and 33·7 per cent. of the proteid escaped absorption. Another got even less favourable results,[4] two-fifths of the proteid being excreted unchanged. Artificial digestion outside the body has yielded similar results.[5] On the other hand, as one would expect, the absorption is considerably better if the mushrooms are taken in the form of powder, but even in that case 29 per cent. of the proteid was lost.[6]

On the whole, mushrooms and other fungi must be ranked with such substances as green vegetables, carrots and black-bread as amongst the wasteful foods.

The **nutritive value** of the fungi has been very much exaggerated. Thus, they have been described as vegetable beefsteaks; it has been pointed out that the Patagonians and natives of Terra del Fuego live largely upon them, and their more extensive use has been urged upon the poorer classes in this country. This is partly owing to the failure to recognise that about one-third of their nitrogenous matter is in a form which is useless for the purposes of nutrition, and partly to ignorance of the very imperfect degree to which such foods are

[1] See analysis by Katherine J. Williams, *Journ. of Chem. Soc.*, lxi. 226, 1892.
[2] Gane, *Food and Sanitation*, April 22, 1899.
[3] Saltet, *Archiv. f. Hygiene*, Bd. 3, p. 443, 1885.
[4] Uffelmann, *Archiv. f. Hygiene*, Bd. 6, p. 105, 1887.
[5] Mörner, *Zeit. f. Physiolog. Chem.*, x. 503, 1886.
[6] Uffelmann, *Archiv. f. Hygiene*, Bd. 6, p. 105, 1887.

capable of being absorbed. Further, the carbohydrates which the fungi contain must be regarded as of very uncertain nutritive value. The fungi cannot, therefore, be looked upon as foods of any greater value and importance than fresh vegetables, and when one considers the high price paid for many of them, such as truffles, they must be regarded as pure luxuries. This conclusion was arrived at as early as 1824 by Dr. Kitchener, who stated in his 'Cook's Oracle' that he did not believe that mushrooms were really nutritious. Pereira expressed a similar opinion twenty years later. It only remains to add that when eaten in large amount they rapidly produce a feeling of satiety, and this must always constitute a further obstacle to their taking serious rank as articles of diet.

Algæ.

This group includes the seaweeds, several varieties of which, *e.g.*, laver, dulse, etc., are occasionally used as foods. The only one which demands special consideration is **Irish** or **Carraigeen moss** (*Chondrus crispus*), which is not only sometimes used as an ordinary article of diet, but finds a place also among the dietetic resources of the sick-room. Irish moss comes into the market in a dried form, and has approximately the following composition (Church):

Water	18·8 per cent.
Nitrogenous matter	9·4[1] ,,
Mucilage, etc.	55·4 ,,
Cellulose	2·2 ,,
Mineral matter	14·2 ,,

Its chief constituent is the substance described in the analysis as 'mucilage,' but which is also known as *lichenin*. This substance is insoluble in cold water, but swells up and dissolves when boiled, and if present in sufficient amount sets to a yellowish jelly on cooling. Its chemical nature is obscure. When boiled with acids it yields a small quantity of sugar, but of what nature is not definitely determined.[2] Of this, however, there is no doubt, that the mucilaginous substance in Irish moss is quite unaffected by the ordinary starch-digesting fluids (saliva and pancreatic juice) met with in the body. For this reason its nutritive value must remain open to grave question, and at present one is only justified in regarding it as a substance capable of yielding a bland and soothing drink which may be of value in irritable conditions of the throat.

[1] In a specimen of Irish moss which I examined, I found only 6·3 per cent. of nitrogenous matter and 16·6 per cent. of ash.

[2] The sugar does not appear to be glucose. I have not found that it ferments with yeast. It gives an imperfect pentose reaction with phloroglucin. The lichenin of Ireland moss gives on hydrolysis a large yield of a reducing sugar, which ferments with yeast, and gives no phloroglucin reaction (see also p. 259).

It is sometimes recommended as a substitute for starch in cases of diabetes; but although it may not aggravate that disease, it is very doubtful whether it contributes in any important degree to the nourishment of the patient. That this is extremely unlikely is rendered still more evident by the fact that Irish moss jelly contains only 3 per cent. of solid matter, the remainder being water. A teacupful of such jelly would furnish only $\frac{1}{8}$ ounce of solid matter, or as much as the weight of a shilling. Whether the nitrogenous matter of Irish moss contributes to the nourishment of the body must also be left undetermined. It is not likely that it is all present in an albuminoid form. The mineral constituents are very abundant, and contain traces of iodine, but not sufficient to exert any effects on nutrition.

Lichens.

The only lichen which we need consider is the so-called **Iceland moss** (*Cetraria islandica*). In its commercial form it resembles Irish moss, but is much darker in colour. According to Church's analysis, its composition is as follows:

Water	10·0 per cent.
Proteid	8·7 ,,
Lichen starch	70·0 ,,
,, acids, etc.	6·3 ,,
Cellulose	3·5 ,,
Mineral matter	1·5 ,,

A more recent analysis of the commercial article dried at 105° C. has been made by Ernest W. Brown,[1] with the following result:

Total nitrogen	0·56 per cent.
Proteid nitrogen	0·32 ,,
Extractive nitrogen	0·14 ,,
Ether extract	1·2 ,,
Cellulose	5·3 ,,
Ash	2·2 ,,
Soluble carbohydrates (as dextrose)	43·3 ,,
Material soluble in 85 per cent. alcohol	16·1 ,,

He describes two kinds of carbohydrates as occurring in the substance: (1) Lichenin, which forms the jelly and yields dextrose on hydrolysis, but is unaffected by digestion and probably does not form glycogen; and (2) iso-lichenin, which is present in much smaller amount and resembles soluble starch, but on digestion yields only dextrins—no sugar.

It is evident from the chemical nature of the substance, from the resistance of its constituents to digestion, and from the small amount of it ever present in a jelly, that its nutritive value must be regarded as practically nil.

[1] *American Journal of Physiology*, i. 455, 1898.

CHAPTER XV

SUGAR, SPICES, AND CONDIMENTS

Sugar

The importance of sugar as an article of diet is so great that it may be well to devote a little space to its special consideration.

Several different varieties of sugar enter into the composition of articles of diet, but for practical purposes they may be divided into two groups: (1) The **sucroses**, known chemically as the di-saccharids ($C_{12}H_{22}O_{11}$), the chief examples of which are cane-sugar (sucrose), beet-sugar, maple-sugar, malt-sugar (maltose), and milk-sugar (lactose); (2) the **glucoses**, or monosaccharids ($C_6H_{12}O_6$), exemplified by grape-sugar (dextrose), fruit-sugar (lævulose), and invert sugar, which is a mixture of those two, and is best known in the form of honey.

We may now consider each of these varieties in some detail.

1. **Cane-sugar**, or sucrose, is the most familiar of all kinds of sugar. It is most commonly derived from certain special grasses, such as the sugar-cane or sorghum, but occurs also in smaller amount in a great many plants and fruits. When derived from other sources than the sugar-cane, special names, such as beet-sugar or maple-sugar, are usually given to it; but it must be distinctly understood that these are chemically indistinguishable from the form of sugar derived from the sugar-cane.

Cane-sugar has been in use in the world as a food for many ages, but it is only within comparatively recent times that it has been manufactured cheaply enough to take an important place in ordinary diets. The following brief history of its introduction into Europe is borrowed from a valuable pamphlet on 'Sugar as Food,' issued by the United States Department of Agriculture:[1]

'Sugar from the sugar-cane was probably known in China 2,000

[1] Farmers' Bulletin, No. 93, 1899.

years before it was used in Europe. When merchants began to trade in the Indies it was brought westward with spices and perfumes and other rare and costly merchandise, and it was used for a long time exclusively in the preparation of medicines. An old saying to express the loss of something very essential was, "Like an apothecary without sugar." Greek physicians several centuries before the Christian era speak of sugar under the name of "Indian salt." It was called "honey made from reeds," and said to be "like gum, white and brittle." But not until the Middle Ages did Europeans have any clear idea of its origin. It was confounded with manna, or was thought to exude from the stem of a plant, where it dried into a kind of gum. When in the fourteenth or fifteenth century the sugar-cane from India was cultivated in Northern Africa, the use of sugar greatly increased, and as its culture was extended to the newly-discovered Canary Islands, and later to the West Indies and Brazil, it became a common article of food among the well-to-do. In 1598 Hentzer, a German traveller, thus describes Queen Elizabeth, then sixty-five years of age: "Her nose is a little hooked, her lips narrow, and her teeth black, a defect the English seem subject to from their great use of sugar." By many the new food was still regarded with suspicion. It was said to be very heating, to be bad for the lungs, and even to cause apoplexy. Honey was thought to be more wholesome, because more natural than the "products of forced invention."'

One of the earliest records of the use of sugar in this country[1] is to be found in the accounts of the Chamberlain of Scotland in the year 1319. Its price at that time was 1s. 9½d. per pound. Since then the consumption of sugar has increased so enormously that each of us in this country now uses about 80 pounds of it annually.

The composition of the sugar-cane and its juice is about as follows:[2]

	Entire Cane.	*Juice.*
Water	71·04	79·4
Sugar	18·02	19·6 (crystallizable). 0·3 (uncrystallizable).
Cellulose	9·56	
Albuminous matter	0·55	0·37
Fatty and colouring matter	0·35	
Soluble salts	0·12	0·25
Insoluble salts	0·16	
Silica	0·20	

In order to separate the sugar, the canes are crushed, and the expressed juice is then bleached by means of sulphurous acid, neutralized with lime, and all albuminous matters coagulated by

[1] See Bannister's Cantor Lectures, 1890.
[2] Thorpe's 'Dictionary of Chemistry,' vol iii., p. 615.

boiling. It is then filtered, evaporated down, and the uncrystallizable sugar (glucose) separated by aid of a centrifuge. In this way the raw sugar is obtained in a crystalline form still mixed with impurities, while the residue is sold as molasses or treacle, or is used to make rum. The chief examples of **raw cane-sugar** are 'Barbadoes,' 'Clayed,' and 'Demarara,' the differences in these depending on the mode of manufacture. 'Barbadoes' is a very dark sugar, while 'Demarara' is characterized by a golden colour and well-defined crystal; it has also a fine flavour, due to its being prepared by the careful treatment of specially selected canes.

Raw sugar is purified by the process of **refining**, which consists in remelting the sugar, filtering it, and clarifying it by means of charcoal. It is then carefully evaporated *in vacuo*. If loaf-sugar is wanted it is run into moulds. Moulded cube-sugar is made in the form of sticks, and afterwards cut into cubes by machinery. Granulated sugars are made in the centrifuge. Other varieties depend on the mode of crystallization and grinding to which the sugar is subjected.

2. **Beet-sugar.**—Fully two-thirds of the 'cane'-sugar commonly used is really derived from the sugar beet. The following account of the growth of the industry is derived from the pamphlet already mentioned:

'Marggraf, a chemist, of Berlin, first discovered in 1747 that beets, with other fleshy roots, contained crystallizable sugar identical with that of the sugar-cane. In 1796 Marggraf's pupil, Achard, erected the first manufactory for beet-sugar, and in 1799 he brought the subject before the French Academy. He manufactured beet-sugar on his farm in Silesia, and presented loaves of refined beet-sugar to Frederick William III. of Prussia in 1797; but the 2 to 3 per cent. of sugar that could be extracted by the methods then in use was too small for commercial success. A new stimulus was given by the sugar bounties of Napoleon in 1806, and methods were rapidly improved, especially in France. Two great difficulties were still to be met: the percentage of sugar present in the beet was small (6 per cent.), and it was separated with great difficulty from the many non-sugar constituents, some of them acrid and of very unpleasant taste. Science now came to the rescue, and a beet was gradually developed having a larger percentage of sugar and a smaller percentage of the undesirable impurities. Barber says that in 1836 18 tons of beetroot were necessary to produce 1 ton of sugar; in 1850 this quantity was reduced to 13·8, in 1860 to 12·7, tons; and in 1889 to 9·25 tons. From 6 per cent. of sugar, as found by

Marggraf, the sugar beet of good quality now contains 15 per cent. and more, 12 per cent. being considered necessary for profitable manufacture.'

The sugar is extracted from the beets by rasping them to a pulp, extracting and evaporating *in vacuo*, with subsequent decoloration by means of animal charcoal.

To the ordinary consumer beet-sugar is indistinguishable from that derived from the sugar-cane, and it has already been stated that to the chemist the two are really identical. There is no evidence for the statement sometimes made, that beet-sugar is more injurious to health than genuine cane-sugar; but I am informed by manufacturers that for some purposes sugar derived from the cane is preferable, *e.g.*, in the manufacture of fruit syrups and British wines. It is said to be less liable to fermentation.

3. **Maple-sugar** is derived from the sugar maple of North America by tapping the bark in early spring and allowing the sap to escape as it flows upward. The sap is evaporated and the sugar allowed to crystallize out while the residue is used as maple syrup. One maple-tree yields about 4 pounds of sugar in a season.

There is no chemical difference between maple-sugar and that derived from the cane or beet, but it contains certain ethereal substances which give it its peculiar flavour. It is probably on the presence of these that the slightly laxative qualities of maple-sugar depend. As a commercial source of sugar the maple cannot compare with either the cane or the beet, and maple-sugar is now chiefly used as a luxury and for the sake of its agreeable taste.

The average composition of these sugars in their raw state is as follows:[1]

Source.	*Water.*	*Cane-sugar.*	*Other Organic Substances.*	*Ash.*
Sugar-cane	2·16	93·33	4·24	1·27
Sugar beet	2·90	92·00	2·59	2·56
Maple	—	82·80		

After being subjected to the process of refining, sugar is practically a pure chemical substance. It is indeed 'the purest food-substance in commerce' (Wynter Blyth).

4. The remaining sugars of this group are malt-sugar, or **maltose**, and milk-sugar, or **lactose**. Both of these, though disaccharids, differ very considerably in chemical and physical properties from the sugars we have been considering. Milk-sugar has already been described (p. 108), and we may defer the study of maltose until we come to malt-extracts (p. 515).

[1] 'Sugar as Food,' p. 12.

Certain substances derived from cane-sugar deserve brief men tion. When strongly heated, sugar melts into a yellowish liquid, and undergoes some physical alteration, so that on cooling it does not crystallize, but forms a transparent, brittle mass, familiar to everyone as **barley sugar**. If heated to a still higher temperature its colour darkens, and it acquires a bitter taste, the product being **caramel**, which is so largely used in cooking operations.

Treacle, molasses, and **golden syrup** are produced as by-products in the manufacture of crystallized sugar. Their syrupy consistence is in part due to the fact that the impurities which they contain prevent the cane-sugar from crystallizing, and partly also to their being fairly rich in uncrystallizable fruit-sugar. The following represents their composition:

	West Indian Molasses.	*Treacle.*	*Golden Syrup.*
Cane-sugar	47·0	32·5	39·0
Fruit-sugar	20·4	37·2	33·0
Extractive and colouring matter..	2·7	3·5	2·8
Salts	2·6	3·4	2·5
Water	27·3	23·4	22·7

It is interesting to compare the proportion of nutritive matter in these with that in malt-extract (p. 516), but to this subject we shall return later.

5. The other great group of sugars is the **glucoses**, or mono-saccharids. The best example of these is **dextrose**, which occurs so abundantly in the grape. When grapes are dried to form raisins, the dextrose separates out, and may be recognised in the raisins in the form of little yellowish-white granular masses. Commercial glucose is usually got by boiling starch with acids. It occurs in a syrupy form. When heated it turns brown, and is used in cookery as 'sugar colouring.' Mixed with egg-albumin, it is largely employed in the preparation of 'icing' and 'fondants' in confectionery and in the manufacture of bonbons.

Fruit-sugar, or **lævulose**, is found, as its name implies, in most fruits. It is characterized by being almost uncrystallizable. It is hardly ever met with in an isolated form in dietetics, but is sometimes administered to diabetic patients, by some of whom it is better borne than any other form of sugar (p. 476).

Invert sugar is a mixture of dextrose and lævulose. It can be prepared from cane-sugar by the action of ferments or by simple boiling, but more readily by boiling with acids. This 'inversion' of cane-sugar, as it is called, goes on pretty rapidly when cane-sugar is boiled with fruit-juice, the active agent being the vegetable

acid of the fruit. Thus, a large proportion of the cane-sugar used in making jam is converted into invert sugar in the process. Seeing that invert sugar has a far lower sweetening power than cane-sugar, one can readily understand how it is that more sugar is required to sweeten a fruit tart if the sugar is added before cooking, as in the Scotch method, than if the sugar is added afterwards, as is commonly done in England. It is important to remember also that invert sugar does not crystallize.

Honey is the most familiar form of invert sugar. It contains about equal parts of dextrose and lævulose, its flavour being due to the presence of small amounts of volatile substances derived from the flowers. The mean composition of pure honey was found by Dr. Sieber to be as follows:

Moisture	19·98 per cent.
Grape-sugar (dextrose)	34·71 ,,
Lævulose	39·24 ,,
Substances other than sugar	5·02 ,,

The comb consists of fatty substances, which are probably incapable of digestion. There is a form of artificial honey in which the comb consists of paraffin wax and the fluid part of commercial glucose, and the latter is often used also for the adulteration of dripped honey. Its use can be detected by the presence of an excess of dextrose in the mixture. Such an artificial product is quite innocuous, but, being much cheaper to produce than the genuine article, it should not be sold at the same price.

The basis of **sweetmeats** is either cane-sugar or one of the glucoses. Sugar-candy is one of the purest. It consists of cane-sugar which has been allowed to crystallize round threads. It contains about 20 per cent. of water and 80 per cent. of crystallizable sugar.

Toffee consists of melted sugar and butter in almost equal proportions. Everton toffee has about 34 per cent. of cane and 27 per cent. of invert sugar, which has been derived from cane-sugar by the prolonged boiling. It is a highly nutritious substance, and makes an agreeable substitute for 'cod-liver-oil and malt' in the case of ill-nourished children.

Chocolate contains about 45 per cent. of cane-sugar, but no dextrose or lævulose. The rest of it is composed of cocoa-powder.

Invert sugar, or a mixture of glucose and albumin, is largely used in the preparation of uncrystallized sweets, such as the creamy matter in the interior of chocolate drops.

The colouring of sweets is derived either from burnt sugar or

from one of the anilin dyes, most commonly eosin. Cochineal is also a favourite colourer. It is interesting to note that these dyes may be excreted in the urine almost unchanged, and cases are on record where patients have been supposed to be passing blood, when they had merely been sucking red sweets. There is no reason to suppose, however, that such substances are in any way harmful to life.

Jams consist essentially of fruit preserved in a strong solution of sugar. We have already seen that the acids of the fruit, aided by the high temperature employed in the course of preparation, bring about the conversion of a considerable proportion of the cane-sugar into the invert form. Home-made jam is boiled for a longer time than the commercial article, and consequently contains more invert and less cane sugar than the latter. Aitchison Robertson[1] gives the proportion of cane-sugar in most home-made jams as 20 per cent., while commercial jams have anything from 10 to 50 per cent. In some home-made jams which he examined the proportion of cane-sugar which had been inverted was as follows:

	Proportion of Cane-sugar inverted.
Strawberry	two-fifths
Marmalade	five-sixths
Bramble	four-fifths
Raspberry	three-fifths
Plum	six-sevenths

The importance of these figures is derived from the fact that the larger the proportion of cane-sugar which has been inverted, the less likely is the jam to interfere with digestion (see p. 268).

Commercial glucose, on account of its incapability of crystallizing, is often used to make jam from inferior fruit or from the remains of fruit, the juice of which has been used to make fruit syrups and jellies. Such jam may have a good appearance, but is deficient in fruit flavour. It is, however, quite wholesome and nutritious.

The gelatinizing power of jellies is due to the presence of pectin in the fruit (p. 246). If boiled too long, the power of gelatinizing is lost, and a syrup results instead of a jelly. In commercial jellies gelatin is sometimes added to prevent this.

Almost half the weight of any given quantity of jam is made up of sugar in some form or another. The nutritive value of jam has already been considered (p. 133).

[1] 'The Value of Saccharine Foods as Articles of Diet,' *Scottish Medical and Surgical Journal*, July, 1898.

Digestion of Sugar.

The first factor which determines the digestibility of a sugar is its chemical form. No matter in what form sugar is consumed in the food, it can only be assimilated as a monosaccharid (dextrose or lævulose). Hence, we find that provision is made in the alimentary canal for the conversion, by means of suitable ferments, of all forms of sucrose (disaccharids) into dextrose and lævulose; *i.e.*, they are inverted. It is evident, then, that from a dietetic point of view we may speak of the sucroses as undigested and the glucoses as pre-digested sugars. It now becomes clear why sweet fruits are such important dietetic sources of sugar. It is because they contain the latter in a form in which it is fit for direct absorption into the blood. For the same reason honey must be regarded as a very easily digested saccharine substance, and the importance of the inversion which cane-sugar undergoes in the manufacture of jams also becomes manifest. The superiority of home-made over commercial jams is also set in a clearer light by reference to these considerations.

The second factor which influences the digestibility of a sugar is *the degree of concentration of its solution*. In strong solution sugar is an irritant to the tissues. In contact with the skin, it is apt to set up superficial inflammation. This is familiar in the form of the eczema which is apt to appear in diabetics from the contact of the sugar-containing urine with the skin, and from the similar condition occurring on the arms of grocers and other persons who have frequently to handle sugar, and it is on account of its irritating properties that sugar cannot be used as a subcutaneous aliment, though otherwise well adapted to fulfil that function. All attempts to use it in that fashion have been frustrated by the pain which it sets up (see p. 524). The same is true of the stomach. Brandl, experimenting on dogs, found that a 5·7 per cent. solution of sugar produced reddening of the mucous membrane; if the concentration was increased to 10 per cent., the mucous membrane became dark red, while a 20 per cent. solution produced pain and great distress. This irritating effect on the mucous membrane is accompanied by the production of much mucus and the pouring out of a highly acid gastric juice. These irritating effects seem to be much more pronounced in the case of cane-sugar than in that of the glucoses. Aitchison Robertson[1] injected 250 c.c. of a 20 per cent. solution of

[1] 'Digestion of Sugars in Some Diseased Conditions of the Body,' *Edinburgh Medical Journal*, December, 1894.

cane-sugar into the stomach of a patient who was suffering from chronic gastric catarrh. Shortly afterwards the patient felt sick, and vomited a very acid fluid which put his teeth on edge. He complained also of heart-burn and flatulence, and of severe pain in the region of the stomach. A solution of invert sugar of the same strength produced no discomfort. The experiment was repeated with similar results in other cases of dyspepsia. The invert sugar produced no unpleasant symptom, and disappeared rapidly from the stomach, while the cane-sugar caused much distress, and remained for a long time.

The greater digestibility of invert sugar is here brought out again in great clearness. Cane-sugar may easily interfere with the digestion of other foods, by reason of the great outpouring of mucus in the stomach which its presence induces. Schüle[1] found that 10 to 30 grammes (2 to 6 lumps) of cane-sugar, when taken with an ordinary test breakfast, produced no appreciable effect on its digestion; but when the quantity was increased to 120 grammes considerable delay of digestion ensued. Seeing, he says, that one can easily take 80 to 100 grammes of sugar at dessert in the form of ices and sweets, a retarding action on the digestion of a meal must not unfrequently be manifested. Experiments by Ogata on dogs confirm these results.[2]

It is evident from all this that, if we wish to avoid the risk of interfering with digestion by the use of sugar, care should be taken that the latter is not consumed in a concentrated form, but that the comparative dilution in which sugar occurs in natural foods, such as fruits and milk, is imitated. This is of special importance in the case of dyspeptics, and the superiority of glucose for such patients over ordinary cane-sugar cannot be too strongly insisted upon.

Another matter affecting the behaviour of different sugars in the stomach is their tendency to undergo **fermentation**. Three varieties of such fermentation may be distinguished: (1) *Alcoholic*, resulting in the production of alcohol and acetic acid; (2) *butyric*, with the formation of butyric acid; (3) *lactic*, the product being lactic acid. Now, it is interesting to note that different sugars vary in the readiness with which they tend to undergo these different forms of fermentation. Some interesting experiments upon this point have been carried out by Aitchison Robertson.[3] He arranges the sugars

[1] *Zeit. f. Klin. Med.*, xxix. 49, 1896.
[2] 'Sugar as Food,' p. 22.
[3] 'Rate of Fermentation of Sugars,' *Edinburgh Medical Journal*, March, 1894.

in the following order, according to the rapidity with which they tend to undergo each variety of fermentation:

Lactic.	*Butyric.*	*Alcoholic.*
Lævulose (most fermentable).	Lævulose (most fermentable).	Maltose (most fermentable).
Lactose.	Maltose.	Invert sugar.
Dextrose.	Dextrose.	Cane-sugar.
Invert sugar.	Invert sugar.	Dextrose.
Cane-sugar.	Cane-sugar.	Lævulose.
Maltose.	Lactose.	Lactose.

The practical deductions which he draws from his observations are these:

1. In dyspepsia the absorption of carbohydrates is delayed, and therefore all sugars tend to ferment.

2. In dyspepsia with lactic acid formation, one should avoid dextrose, lævulose and invert sugar, and use cane-sugar, maltose and lactose in moderate amount.

3. In butyric fermentation lactose should be preferred.

4. In alcoholic and acetic fermentation one should forbid invert sugar and lævulose, and give lactose.

It will be observed that, of all sugars, lactose is least liable to fermentation. This is another point in favour of the value of a milk diet in stomach complaints.

The last point connected with the influence of sugar on the digestive organs is its supposed **injurious effects on the teeth.** The impression that sugar-eating is bad for the teeth is so widespread that one can hardly suppose it to be devoid of all real basis. It must be admitted, however, that the supposition is not supported by any very conclusive observations. If sugar does destroy the teeth, it probably does so indirectly by lingering in the crevices of the mouth, and leading to the production of acids which eat away the enamel.

Assimilation of Sugars.

The fate of sugar after entering the blood is to be converted by the liver into glycogen. What becomes of it after that is still disputed, but everyone is agreed that glycogen is the form in which sugar is stored in the body, for a time, at least. Now, it has been found by physiological experiment that it is not all sugars which are capable of being converted into glycogen. It is only those which can be *directly* fermented by yeast—fermented, that is to say, without being first changed into invert sugar.[1] Of the sugars commonly

[1] See Cremer, *Zeit. f. Biologie*, xxix. 484, 1892, and xxxii. 49, 1895; also Fritz Voit, *Deut. Archiv. f. Klin. Med.*, lviii. 523, 1897, and Achard and Weil, *Archives de Méd. Expér.*, 1st series, x. 816, 1898.

consumed, cane-sugar and lactose are not directly fermented by yeast, and, in order that they may be stored up as glycogen, provision has to be made for their previous inversion. This is met, as we have seen, by the production of certain inverting ferments in the intestine which act on these sugars. If, however, these ferments happen, in any particular case, to be of feeble activity while the absorptive power of the intestine is great, some of the sugar may reach the blood unchanged, and, being incapable of conversion into glycogen, straightway appears in the urine. Even in the case of the directly fermentable sugars, if a large quantity is absorbed in the course of a short time, the glycogen-forming power of the liver may be unable to keep pace with the demands made upon it, and some of the sugar will appear in the urine. There results from this what is termed **alimentary glycosuria.** By giving large quantities of a different sugar on an empty stomach, and observing whether or not glycosuria results, one has been able to determine what may be called the *assimilation limit* of each—that is to say, the maximum quantity which can be consumed at one time without the overflow of any of the sugar into the urine taking place. These maximum amounts are about as follows:

For lactose	120 grammes.
For cane-sugar	150 to 200 grammes.
For lævulose	200 grammes.
For dextrose	200 to 250 grammes.

Lactose, therefore, is the least assimilable of all sugars, and if taken in excess is the most likely to result in the production of glycosuria.

It must further be borne in mind that the assimilation limit is not the same for all individuals. Some people are able to convert more sugar into glycogen than others. It has been stated that persons with a low assimilation limit are potential diabetics; that is to say, they are more liable than others to become the victims of diabetes mellitus.

There is another chemical fact relating to the assimilation of sugars which is of some practical interest, and it is this: Experiments have shown that the only sugars capable of direct fermentation, and therefore of conversion into glycogen, are those which contain either three carbon atoms or a multiple of that number. Those which contain five, seven, or any other number of carbon atoms cannot be converted into glycogen, and accordingly, should they gain access to the blood, are at once excreted in the urine. Now, sugars with five carbon atoms (pentoses) occur with considerable frequency in certain fruits, and hence pentosuria, as it is

termed, is a not infrequent result of the free consumption of such foods.

Notwithstanding all this, it must be noted that, if sugar be taken along with other food, and distributed uniformly over the day, very large quantities can be consumed without the danger of exceeding the assimilation limit. Vaughan Harley was able to take a pound of cane-sugar daily—with injurious results as regards his digestion, it is true, but without producing glycosuria. As a general rule, one may assume that ¼ pound can be taken daily without any bad results at all, but the exact amount must of necessity depend to a large extent on the muscular activity of the subject.

Nutritive Value and Economy of Sugar.

We have seen that refined sugar is to be regarded as a practically pure carbohydrate. That being so, its food value must be high, for every gramme of it will yield 4·1 Calories of energy. An ordinary lump of loaf-sugar weighs 5 grammes, and yields therefore fully 20 Calories. Four such lumps contain as much carbohydrate as a medium-sized potato. It is evident from these considerations that even the amount of sugar ordinarily added to a cup of tea may contribute in no small degree to the supply of energy required by the body daily. A pound of butter will yield about twice as much energy as a similar weight of sugar, but at nearly four times the same cost, for sugar is one of the cheapest fuel foods—perhaps *the* cheapest—which we possess, a shilling spent on it yielding 11,000 Calories, or more, even, than can be obtained in the form of bread for a similar expenditure.

This great cheapness of sugar is a development of recent years, and can hardly be without far-reaching effects on the national health. It tends to make us consume more carbohydrate and less fat, for fat is always a dear form of food. Whether this is an advantage it would be difficult to say. It is true that sugar can replace fat as a fuel in the proportion of 2¼ parts of the former to 1 of the latter, but it does not follow on that account that sugar can perform all the functions in the body which are usually fulfilled by fat, provided that proportion be observed. We have already learnt (p. 22) that sugar is more rapidly burnt up in the body than fat, and is on that account a more efficient proteid-sparer than the latter. This rapid oxidation is favoured by the ease with which sugar is absorbed, and, interfering as it does with the complete destruction of proteids, probably explains the bad effects sometimes observed from the use of sugar in gout

and gravel (p. 495). The relative advantages of fat and sugar as fat-formers is another unsettled point. The highly fattening properties of sugar are undoubted; it is probably not only itself capable of being transformed into fat, but spares the body fat and part of that in the diet from combustion; but whether the fat so formed is as useful as that which can be stored up from the fat in the diet is a question which physiology is not yet in a position to solve. The point is one of some practical importance in the feeding of convalescents, and in the selection of cod-liver-oil or malt as a fattening agent.

Of this, however, there can be little doubt, that the great cheapness of sugar must have a favourable influence on the health and growth of children, for it ensures to them an ample supply of the body fuel which they so much need, and which the dearness of fat is apt to make unattainable. It has the advantage, too, of being a form of fuel which few children are likely to refuse, and that is far from being true of fat.

It is **as a muscle food**, however, that sugar is of special importance. We have already learnt (p. 38) that the carbohydrates are probably the chief source of muscular energy, and the sugars, on account of the ease and rapidity of their absorption, are better calculated to fulfil this function than any other member of the carbohydrate group.

It is interesting to note that Brillat-Savarin pointed out long ago that 'the English give sugar to their blood horses in order to sustain them in the trials to which they are subjected.' To Swiss guides and Arctic explorers, too, the value of such a saccharine food as chocolate has long been familiar. It was not until the year 1893, however, that Mosso first put the value of sugar as a muscle food to the test of experiment. By means of the ergograph he was able to show that sugar has a notable effect in lessening muscular fatigue. The subject was then taken up by Vaughan Harley, who found, working under Mosso's direction, that if he took 17½ ounces of sugar a day his power of doing work was increased 61 to 76 per cent. He showed also that the administration of sugar delays the onset of fatigue, and that its effects are rapidly exerted, the maximum influence being reached in about two hours. Schumburg[1] was able to confirm these results as regards *extraordinary* muscular exertion. Similar experiments have recently been performed by Prautner and Stowasser,[2] who found that when sugar was added

[1] *Archiv. f. Anat. und Physiol.*, 1899, Sup. Bd., p. 289.
[2] *Centralb. f Inn. Med.*, No 7, 1899.

to their diet their power of doing work was increased, while fatigue and nitrogenous waste were lessened. They conclude that sugar is a specially valuable food for persons who have to perform a single muscular effort, and especially if they are obliged to do so in a state of exhaustion.

The results of these scientific experiments, which were carried out with due regard to all possible sources of fallacy, have led to an extensive practical trial of sugar as a food for persons engaged in muscular labour. Two examples must be mentioned. During the autumn manœuvres of the German army a couple of years or so ago, a number of the men were given 10 lumps of sugar daily, in addition to their ordinary rations. The trial extended over five weeks, and it was found that the soldiers who had been supplied with sugar marched better and suffered less from hunger, thirst, and fatigue than their fellows who were not so supplied. As a result of the experiments, the surgeon in charge recommended that the sugar ration for soldiers should be raised to 60 grammes per day.

The other example illustrating the practical value of sugar as a muscle food is to be found in the experience of certain rowing clubs in Holland. They found sugar to be a very valuable food in training. The rowers who used it always won, on account of their superior powers of endurance, and it seemed to counteract the bad effects of an exclusively meat diet, so that the men did not become 'stale.'

'One case, as given in detail, is very interesting. Two schoolboys, seventeen and nineteen years of age, with only two hours a day for practice, at the end of two months entered for the rowing races. No change had been made in their diet except that they ate as much sugar as they wished, sometimes as much as one-third of a pound at the time of their daily exercise. One of them, however, did not make this addition to his diet until the third week, when he began to show all the signs of overtraining—loss of weight, and a heavy, dull feeling, with no desire for study. On the third day after beginning the use of sugar these symptoms disappeared. At the time of the race both youths were in fine condition, and were victorious over their antagonists, who did not believe in the use of sugar. No bad after-effects were observed.'[1]

It certainly seems as if it would be worth the while of captains of football teams to try the effect of serving round small cups of black coffee, strongly sweetened with glucose, at 'half-time,' instead of the usual lemon. They would probably be rewarded by the greater endurance of their men in the second half of the match.

[1] 'Sugar as Food,' p. 18.

Spices and Condiments.

The spices, condiments, and flavouring agents generally, are not, as a rule, *foods* in the strict sense of the term; that is to say, they are not capable of supplying the body with building material or energy. None the less, however, they are essential constituents of the diet. Their importance rests upon the power which they possess of improving appetite, and, by so doing, of increasing the digestive power. To the healthy man of vigorous appetite their presence is less essential. It has been found by experiment that meat from which all the flavouring ingredients have been extracted by prolonged boiling is as well digested by healthy men as fresh meat itself,[1] in spite of the fact that it was eaten with but little relish.

To persons of jaded appetite, however, and to invalids and convalescents, the flavouring agents of the food are very powerful aids to digestion, and no adjustment of the diet in such cases can be regarded as satisfactory which leaves this consideration out of account. Their presence justifies the inclusion in the regimen of many substances which are otherwise of little nutritive value, such, for example, as beef-tea.

The recent experiments of Pawlow[2] have placed the mode of action of these substances in a clearer light, and tend to enhance our sense of their importance. They appear to act partly through the organs of taste, in part reflexly, and in part also by a direct local action on the stomach. In all of these ways the appetite is aroused and the secretion of gastric juice promoted. The direct irritant effect which some of them have upon the stomach contra-indicates their use in certain forms of dyspepsia in which the mucous membrane is in a state of congestion or slight catarrh. Many of them, too, exert a similar influence upon the organs of excretion, and for that reason they should be avoided by patients who are suffering from congestion of the kidneys or nephritis, or, indeed, inflammation in any part of the genito-urinary tract.

We have not space to study in detail the chemistry and composition of the vast number of flavouring agents which enter into the diet. It will be sufficient for us to glance for a moment at some of those in commonest use.

Mustard is derived from the seeds of the black or white mustard-

[1] Pettenkofer and Ziemssen's 'Handbuch,' Part I., p. 94, 1882.
[2] 'Die Arbeit der Verdauungsdrüsen,' Wiesbaden, 1898, chapter viii.

plant (*Brassica nigra* and *alba*). The seeds of the white plant are the larger. They contain an acrid principle, but no essential oil. The black seeds contain a substance called myronate of potash, along with a ferment (myrosin), and these, when moistened with water, interact, producing the pungent essential oil to which the characteristic sharpness of mustard is due. The horse-radish (*Cochlearia armoracia*) contains an oil similar to that of black mustard.

Black pepper is derived from the unripe berries of the *Piper nigrum;* white pepper is produced from the ripe fruit. The seeds contain an essential oil and an alkaloid (piperine), both of which contribute to the pungent taste of the substance. Cayenne pepper is derived from the pods of capsicum ; the small pods constitute chillies.

The basis of **vinegar** is acetic acid. Every 100 c.c. of good vinegar should contain 5 grammes of the acid, calculated in the glacial form. In genuine vinegars the acetic acid is produced by the oxidation of alcohol by a fungus (the *Mycoderma aceti*), while in **wood vinegar** it is produced by the destructive distillation of wood, the product being often coloured by the addition of burnt sugar. The source of the alcohol in genuine vinegars varies. In the best varieties weak wines are the source, and such vinegars retain a certain amount of 'bouquet,' derived from the wine. Solutions of alcohol derived from the fermentation of malt—dilute beers, in fact —are, or ought to be, the source of **malt vinegar**; but this term is often used by manufacturers in a very misleading fashion, for in recent years dilute spirit derived from sugar or molasses has come much into use as a substitute for malt. It can scarcely be maintained that such a substitution is in any way injurious to health. Vinegar is often distilled, in order to make it keep better. The distillate contains the acetic acid, along with traces of alcohol and ether. This variety is said to be very popular in Scotland (Allen).

In addition to being a condiment, vinegar has an important action in softening the fibres of hard meat and the cellulose of green vegetables. Hence its use with such articles as crab and its addition to salads. Although the acetic acid which vinegar contains is ultimately oxidized in the body, with the production of alkaline compounds, there is still reason to believe that it has an unfavourable influence in gout, and may even precipitate an attack if freely indulged in.

It only remains to add that sugar itself, in addition to its value as a food, is one of the most important of the condiments in common use, and, like all of these, is able to stimulate appetite and digestion

if used in moderation. This justifies the consumption of sweets at dessert. Chemical substitutes for sugar which possess its flavouring qualities without its food value are **saccharin** (benzoic sulphamide) and **dulcin** (sucrol). These have many hundred times the sweetening power of sugar, but are of no use as foods. They are used to replace sugar as a flavourer, chiefly by diabetic, gouty, and obese patients.

CHAPTER XVI

MINERAL CONSTITUENTS OF THE FOOD

THE human body contains about 7 pounds of mineral matter, of which about five-sixths is in the bones. An analysis of the whole body would yield about 5 per cent. of ash. It is obvious from this that the mineral ingredients of the diet are important building material for the body, and are therefore to be regarded as foods in the strictly scientific sense of the term.

The chief mineral substances required in the food are sodium, potassium, calcium, magnesium, and iron, along with phosphorus, chlorine, sulphur, and traces of such substances as silica, fluorine, and iodine.

So necessary are these for maintaining intact the fabric of the body that one finds that death ensues within about a month if the supply of them is entirely cut off, even although all the other constituents of a normal diet are supplied as before.

It being granted, then, that the mineral constituents of the food are important as tissue-builders, the question may next be asked, Are they of any value as sources of heat or energy? As regards the former, the reply is in the negative. The mineral substances in the food enter the body in a too highly oxidized form to be capable of yielding any heat in the tissues.

As regards the question of **supplying energy**, the reply is more doubtful. It is true that the substances under consideration cannot yield energy by oxidation in the way that the proteids, fats and carbohydrates do, but there is reason to believe that they *are* able to act indirectly as sources of energy in virtue of the osmotic properties which they possess. It is found,[1] for example, that ordinary soup, by reason of its salts, possesses an osmotic pressure of from 7 to 9

[1] Koeppe, 'Die Bedeutung der Salze als Nahrungsmittel:' 68ten Versamm. Deut. Naturforscher, p. 80, 1896 (Inn. Med.).

atmospheres. Now, the body fluids have an osmotic pressure of only 6 atmospheres, and thus half a pint of soup will raise the osmotic pressure in the body by fully half an atmosphere. In this way absorption and the diffusion of the body fluids is aided, and such an action is equivalent to the supply of a certain amount of energy to the body. Thus it is that the mineral constituents of the diet may claim to rank as 'foods' on two grounds: they are builders of tissue and they are sources of potential energy as well

We have next to inquire, **What amount of mineral matter must be supplied to the body daily?** To this inquiry no definite reply is forthcoming. We cannot tell how much of these substances is required for healthy nutrition in as precise a manner as we can calculate the need for carbon or for nitrogen, mainly for this reason—that many of the waste mineral matters of the body are excreted by the intestine, and we have no means of telling what proportion of these has merely escaped absorption, and how much has been excreted from the blood after playing a part in metabolism. This, however, one *can* say, that the amount of mineral matter found in an ordinary mixed diet is sufficient—nay, much more than sufficient—for all the needs of the body, and that amount is about 20 grammes, exclusive of such arbitrary additions as salt.

As regards the *form* in which the mineral constituents enter into an ordinary diet, it may be said that many, if not, indeed, most of them, are in a state of organic combination. Thus, we find calcium and phosphorus organically combined in milk, iron in yolk of egg and meat, sulphur in all proteid-containing foods, and so on. It would appear, although the reason for it is obscure, that such organic mineral compounds are of special value in nutrition. It cannot be maintained, however, that it is *only* in such forms that mineral matter can find access to the blood. Experiment has shown that even such a substance as carbonate of lime is absorbed to some extent, for its administration is followed by an increased excretion of calcium in the urine,[1] and the success which attends the treatment of cases of chlorosis by purely inorganic preparations of iron compels us to believe that the metal is capable of being absorbed in that form.

Notwithstanding these facts, it was found by Lunin that mice fed on desiccated milk lived quite healthily, whereas other mice which were given pure casein plus all the salts of milk in an inorganic form died.[2] No explanation of such results can be given, but they

[1] Strauss, *Zeit. f. Klin. Med.*, xxxi. 493, 1897.
[2] See also Socin, *Zeit. f. Physiolog. Chem.*, xv. 93, 1891.

show that the form in which the mineral constituents of the food are presented to us is by no means a matter of indifference.

We may now pass on to consider the amount and kind of the mineral constituents met with in different articles of diet. It would serve no useful purpose, however, to present the reader with analytical tables professing to exhibit the precise percentage of the various components of the ash of different foods, for the reason that these are subject to very great fluctuations in kind and amount. This is specially true of vegetable foods, on the mineral ingredients of which the mode of cultivation and nature of the soil have such a marked influence. It will be more useful to take up the principal mineral substances required by the body separately, and to point out in general terms what articles of diet are richest in them. Let us begin with calcium.

Calcium.—It has been calculated, from analyses of human milk, that an infant requires about ⅓ gramme of lime daily. The adult, owing to cessation of the growth of the bones, requires less. Deficiency of lime in the food of an infant leads to softening of the bones; but this, though an element in rickets, is not really the root of that disease, for nothing is more certain than that an infant may suffer from rickets even although there has been an actual excess of lime salts in its food.

In later life various pathological conditions have been ascribed to an excessive consumption of calcium in the food. Amongst these are calculus, atheroma[1] and other calcareous degenerations, and habitual constipation. It must be admitted, however, that there is but little real evidence for such views. It is exceedingly doubtful whether the intestine ever absorbs more of any mineral substance than the tissues require, and if there is a tendency to the accumulation of such substances in any particular situation, the fault must be ascribed to some local change in the tissues, rather than to any undue increase of absorption.

Of common articles of diet, the richest in calcium is milk. It contains 1½ grammes of lime in every litre; or, put otherwise, there is more lime in a pint of milk than in a similar quantity of lime-water. Next to milk come eggs, then the cereals—and especially rice—and then some vegetables, such as radishes, asparagus and spinach. Hard waters also must be regarded as important dietetic sources of calcium.

[1] See Rumpf, *Berliner Klin. Wochensch.*, No. 13, 1897. This author recommends atheromatous subjects to adopt a diet poor in calcium salts, such, for example, as bread, fish, meat, apples and potatoes.

Foods poor in lime are meat (but only if derived from a fully-grown animal—veal, for example, being comparatively rich in calcium[1]), fish, fruits and potatoes.

The importance of milk and eggs as foods for growing children will be apparent from these facts, while if one should for any reason desire to construct a dietary containing a minimum of lime, it would be well to draw its ingredients from the members of the second group.

Magnesium is usually present in foods in the same proportion as calcium. There are exceptions to this rule, however, for in milk magnesium is less, and in meat rather more, abundant than calcium, while in bread there is actually five times as much of the former as of the latter.[2]

Iron is one of the mineral constituents of the diet of which one may say that it is always present in an organic form. It is also mainly excreted in the fæces, and this fact has led to great difficulty in attempting to estimate the amount of it required by the body daily. Roughly speaking, there are about 10 milligrammes of the metal contained in an ordinary mixed diet (Stockman), and that quantity must therefore be regarded as sufficient to meet all physiological demands.

It is difficult to give precise figures as to the amount of iron present in different articles of diet. In animal foods it depends very much on whether the animal was bled or not, while in vegetable foods it varies very greatly with the amount of iron in the soil. Bunge arranges some common foods in the order of their richness (not the richness of their ash) in iron as follows:

Spinach.
Yolk of egg.
Beef.
Apples.
Lentils.
Strawberries.
White beans.
Peas.
Potatoes.
Wheat.

Boussingault[3] gives the following proportions of iron in 100 parts of the following foods examined in the fresh condition:

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[1] See Katz, *Pflüger's Archiv.* 63, p. 1, 1896.
[2] See Richet's 'Dictionary of Physiology.'
[3] *Comptes Rendus*, lxxiv. 1355, 1872.

PROPORTION OF IRON PER 100 PARTS OF FRESH SUBSTANCE.

Blood of ox	0·03750
,, pig	0·06340
Beef	0·00480
Veal	0·00270
White fish	0·00150
Egg	0·00570
Wheaten bread	0·00480
Haricots	0·00740
Oats	0·01310
Lentils	0·00830
Potatoes	0·00160
Milk	0·00180
Carrots	0·00090
Maize	0·00360
Rice	0·00150
Apples	0·00200
Spinach	0·00450
Cabbage	0·00390
Burgundy	0·01090 in one litre.
Beer	0·00400

Stockman has pointed out[1] that these results are too high, probably from faulty methods of analysis. He gives the following amounts of iron in some common foods:

1 pint of milk	2·2	milligrammes iron.
100 grammes of oatmeal	3·1	,,
300 ,, fine bread	1·8	,,
280 ,, common bread	1·1	,,
120 ,, beef-steak	4·7	,,

From the results available, it may be concluded that beef and yolk of egg[2] are foods richest in iron, while milk and its derivatives, such as cheese, are amongst the poorest; but even 5 pints of milk would supply the 10 milligrammes of metal required in the daily diet. Oatmeal and Egyptian lentils are amongst the richest in iron of vegetable foods, but bread, rice, potatoes and spinach also contain a good deal.

Amongst beverages, some mineral waters—*e.g.*, Kronthal (green label)—contain a good deal of iron, and tea-leaves also are very rich in it, but probably little of the metal finds its way into the infusion. Wines are poor in iron, even the so-called ferruginous varieties having but a small proportion.

That the habitual consumption of foods poor in iron may lead to anæmia is possible, though it is difficult to imagine a diet that would not contain the small amount of the metal required daily. Verdeil and Subbotin, however, have certainly found that the ash of the

[1] *Journ. of Physiolog.*, xviii. 484, 1895, and xxi. 55, 1897; also *Brit. Med. Journ.*, December 14, 1895.

[2] See Katz, *Archiv. f. d. Gesam. Physiolog.*, lxiii. 1, 1896.

blood of dogs fed on meat contained much more iron than that of animals nourished on bread; and V. Hoesselin has shown that if young animals only receive as much iron as adults they become anæmic.

On the other hand, once any marked deficiency of iron in the blood exists, it is almost impossible to make it good by merely dietetic means; for no food is rich enough in iron salts to be able to accomplish the object in view. Hence, a knowledge of the amount of iron contained in different foods is, after all, of but little therapeutic value.

Sodium and Potassium.—Sodium is required in the body for the proper constitution of its fluids; potassium for the construction of cells, and specially, perhaps, of the red blood cells and the muscles. Young animals deprived of potassium do not develop good muscles. As regards the amount of sodium and potassium contained in different foods, it may be said that the vegetable group is richest in the latter, and the animal group in the former.

Bunge gives the following table of proportions:

To 1 equivalent of sodium there is—

In yolk of egg	1 equivalent of potassium.
,, milk	0·8 to 6 equivalents of potassium.
,, veal	4 ,, ,,
,, wheat	12 ,, 23 ,, ,,
,, potatoes	31 ,, 42 ,, ,,
,, peas	44 ,, 50 ,, ,,

It used to be believed that a deficiency of potash salts in the food was the main cause of scurvy. This belief, however, is now discredited, and it is probable that potash is useful, not so much for its own sake as for the vegetable acids with which it is combined, and which, by their oxidation, help to maintain a proper degree of alkalinity in the blood.[1] Green vegetables and fruits are a peculiarly valuable source of such salts.

Sodium is chiefly taken in the form of sodium chloride, or **common salt.** Of this most people consume about 20 grammes daily, which is probably at least ten times as much as is really necessary to meet the needs of the body. There are not wanting people who maintain that this excessive consumption of salt is not only needless, but even harmful.[2]

This, however, appears to be an extreme view. It may be admitted—for the experience of those who refuse to add any salt to their food amply proves it—that the amount of sodium chloride

[1] See Wright 'On the Pathology and Therapeutics of Scurvy,' Army Medical Reports, p. 394, 1895.
[2] See Mrs. Leigh Hunt Wallace's 'Salt in its Relation to Health and Disease.'

contained in a natural form in ordinary foods is quite sufficient for our needs; but there is no proof that an extra addition of salt in the form of a condiment is in any way injurious to health. On the other hand, it is equally far from being proved that such addition conduces in any way to the well-being of the body. It has been asserted, for instance, that the addition of salt to the food aids digestion (Ogata), but more recent and exact experiments have shown that—in health, at least, and in moderate doses—salt has very little real influence on digestion at all, while in large quantities it actually delays the process.[1] If, moreover, sodium chloride is entirely removed from the food, the secretion of hydrochloric acid is lessened, or even arrested altogether, and upon this basis it has been urged that one should limit the use of salt in cases of hyperacidity of the stomach. Where, on the other hand, appetite is poor and digestive power feeble, the moderate use of salt in the food may act as a digestive stimulant in the same way as any other condiment. There is also reason to believe that it may slightly aid the absorption of food.[2]

On the general processes of nutrition in the body, salt seems to be equally devoid of any pronounced effects. On the one hand it has been maintained that it acts as a cell stimulant,[3] while on the other it has been denied, on seemingly equally good grounds, that it has any distinct influence on metabolism at all. The latest and most conclusive experiments[4] tend to show that any action salt may have is in the direction of lessening nitrogenous waste, *provided a sufficiency of water is supplied at the same time.* From all the evidence, we may safely conclude that the artificial addition of salt to the food has either no appreciable influence on health at all, or, if it has any, it is an influence which must be described as favourable rather than otherwise.

The craving for salt as an addition to the diet seems to be specially strong amongst vegetable-feeders. An ingenious explanation of this fact has been advanced by Bunge on the lines that the large proportion of potassium in vegetable substances would tend to drive all sodium out of the body were the latter not constantly reinforced by the addition of salt to the food. This theory has been strongly criticised by Forster and others, and it is doubtful if it can be regarded as tenable—at least, in the extreme form in which it was brought forward by its distinguished author. Whatever the explana-

[1] See Pawlow, 'Die Arbeit der Verdauungsdrüsen,' and Schüle, *Zeit. f. Klin. Med.*, xxviii. 492, 1895, and xxix. 49, 1896.
[2] Gabriel, *Zeit. f. Biolog.*, xxix. 554, 1892.
[3] Garnier and Lambert, *Archives de Physiolog.*, 30, p. 421, 1898.
[4] Walther Straub, *Zeit. f. Biolog.*, xxxvii. 527, 1898.

tion, however, the fact remains that the artificial addition of salt is apparently more necessary in the case of people who live mainly on vegetable products than in those who consume a mixed diet.

Phosphorus.—The importance of phosphorus as a building material in the body can scarcely be overrated. Wherever growth is most active there most phosphorus is found. It enters into the composition of all cell nuclei, and it is abundantly present in the bones and in the central nervous system. One would naturally expect, therefore, that wherever the building up of such tissues is going on rapidly a large supply of phosphorus will be required in the food, and it is not surprising to find that the development of young animals which are deprived of it is apt to be seriously impaired. Hence the great importance of a due supply of phosphorus in the food of growing children.

The **percentage of phosphoric acid** (P_2O_5) in some fresh foods is as follows:[1]

Vegetable.		*Animal.*	
Carrot	0·036 per cent.	Pork	0·160 per cent.
Turnip	0·058 ,,	Milk	0·220 ,,
Cabbage	0·089 ,,	Beef	0·285 ,,
Potato	0·140 ,,	Eggs	0·337 ,,
Chestnuts	0·200 ,,	White cheese ..	0·374 ,,
Barleymeal ..	0·230 ,,	Mutton	0·425 ,,
Haricots	0·924 ,,	Gruyère cheese ..	1·350 ,,

The superiority of most animal foods in respect of this constituent is at once apparent.

The phosphorus contained in foods is, for the most part, present in an organic form of combination, sometimes of a very complex sort, but in part also in an inorganic form as phosphates of the alkalies or earths.

There is reason to believe that the organic forms are the more valuable for contributing to the growth and repair of tissue. Examples of these are the chemical substances nuclein, lecithin, glycero-phosphoric acid, and phospho-carnic acid, all of which are probably valuable dietetic sources of the element. The foods richest in these are such articles as yolk of egg, thymus, fish-roe, calves' brains, and the germ of wheat.

It is doubtful, on the other hand, whether the inorganic compounds containing phosphorus are of much value in the body. They seem to be almost immediately excreted by the kidney or bowel, probably without exercising any important influence on metabolism.

[1] Girard, *Comptes Rendus*, cxxii. 1387, 1896.

One can, therefore, hardly approve of the addition to the diet of phosphates in their inorganic form. An example of such an addition is found in **Cerebos salt**, which is a mixture of 4 parts of phosphates derived from bran with 96 parts of common salt. In spite of their vegetable origin, the phosphates in such a preparation must be regarded as being present in a purely inorganic form, and are therefore of very doubtful utility. The recommendation of such preparations is based upon the groundless assumption that an ordinary mixed diet is too poor in phosphorus to be able adequately to supply our need of that substance. It may be remarked in this connection that we know of no diseased condition which can be clearly traced to a deficiency of phosphorus in the diet. This is true, indeed, not of phosphorus alone, but of all the other mineral ingredients of the diet with the exception of iron, and possibly also of calcium. A deficiency of iron in the food may, as already remarked, lead to the development of anæmia, and too little lime in the food may cause the bones of children to become soft; but with these rather doubtful exceptions it may be safely assumed that any ordinary diet will amply provide for all the mineral matter we require. If one should for any reason think it advisable to increase the proportion of phosphorus in the food, it would be wiser to have recourse to those articles already mentioned in which it is present in an organic form, rather than to pour into the body inorganic compounds which will probably be excreted from it just as they entered. That such organic forms are well absorbed there is now no doubt.[1]

Oxalic acid, though not strictly speaking a mineral substance, may be conveniently considered here, for it is usually present in the diet in the form of oxalate of lime. Esbach gave the following table of the amount of oxalic acid in different articles of food:

	Per 1,000.
Black tea infused 5 minutes	2·060
Cocoa-powder	3·520 to 4·500
Pepper	3·250
Coffee	0·127
Parsley	0·006
Haricots	0·312
Common beans	0·158
Potatoes	0·046
Good bread	0·047
Crust	0·130
Crumb	0·120
Buckwheat flour	0·171
Barleymeal	0·039
Maize flour	0·033
Sorrel	2·740 to 3·630
Spinach	1·910 to 3·270

[1] See Bergell, *Fortschr. der Med.*, xvi. 1, 1898.

	Per 1,000.
Rhubarb	2·466
Brussels sprouts	0·020
Cauliflower	0·003
Beetroot	0·390
French beans	0·060 to 0·212
Salsifies	0·070
Tomatoes	0·002 to 0·052
Carrots	0·027
Chicory	0·103
Dodder	0·045
Endive	0·017
Lettuce	0·016
Dried figs	0·270
Currants	0·130
Prunes	0·120
Gooseberries	0·070
Plums	0·070
Raspberries	0·062
Oranges	0·030
Lemons	0·030
Cherries	0·025
Strawberries	0·012

It will be observed from the table that oxalic acid occurs in relatively large amounts in tea, coffee, spinach, rhubarb, sorrel, and pepper. Tomatoes are sometimes said to be rich in it, but this would appear to be an error. Their sour taste is due to the presence of citric acid. An animal diet diminishes the excretion of oxalic acid owing to the small amount of it which animal foods contain.[1]

There would seem to be little doubt that the consumption of foods rich in oxalic acid may be a cause of the production of oxalic calculus. Dr. Prout, for example, states that he has seen well-marked instances in which an oxalate of lime nephritic attack has followed the free use of rhubarb (in the shape of tarts, etc.), particularly when the patient has been in the habit at the same time of drinking hard water. On the other hand, the condition of so-called oxaluria seems to have no relation to the amount of oxalates in the urine, but to be merely a variety of acid dyspepsia.

Sulphur is present in the food almost entirely in a state of organic combination—chiefly in proteids. The amount of it present in different proteids varies considerably, as is shown by the following analyses of dry proteids.[2] There is in—

Dried egg-white	1·80 per cent.
,, syntonin	1·80 ,,
,, albumin of wheat	1·55 ,,
,, ,, peas	0·40 ,,
,, gluten	0·70 ,,

[1] J. C. Dunlop, *Journal of Pathology and Bacteriology*, iii. 389, 1896.
[2] Richet's 'Dictionary of Physiology.'

We know nothing of the advantages or otherwise of an increase or diminution of sulphur in the food.

Chlorine is taken in almost entirely in the form of sodium chloride, or common salt. Except as a source of hydrochloric acid, nothing is known of its uses in the body, but the peculiar behaviour of the chlorides in some acute fevers would point to some special rôle attaching to them in metabolism.

Iodine is present in small quantities in fish.[1] Thus, herring contain 2 milligrammes per kilo, mussels 1·9 milligrammes, salmon 1·4, ling and cod 1·2, and oysters 1·2. The only situation in the body in which this element has been detected is the thyroid gland, and the significance of its presence in the food is as yet quite obscure, though it may one day prove to be of some importance.

Fluorine and **silica** are present in the body in small quantities, chiefly in the teeth and bones. Vegetable foods, and especially the cereals, are their most abundant source in the diet.

The question of the **acidity or alkalinity of foods** may be conveniently dealt with here. According to the reaction of their ash, foods may be divided into three groups:[2] (1) Acid foods, *i.e.*, those which leave on incineration an acid-reacting ash; (2) neutral food, with neutral ash; and (3) alkaline foods, the ash of which is alkaline in reaction.

Examples of these groups, arranged in the order of their acidity or alkalinity respectively, are as follows:

Acid Foods.	*Neutral.*	*Alkaline.*
Oats.	Sugar.	Carrot.
Barley.	Vegetable oils.	Turnip.
Beef.	Animal fats.	Potato.
Wheat.		Onion.
Eggs.		Milk.
Rice.		Blood.
Maize.		Peas.
		Lemon-juice.
		Orange-juice.
		Beans.

Wright is of opinion that the exclusion from the diet of a sufficient quantity of 'alkaline' foods leads to the development of scurvy and other diseases characterized by a diminution of blood coagulability. It is not improbable, also, that the proportion of acids or alkalies in foods may have important bearings on gout, but a discussion of the question would lead us into the sphere of too many controversial matters.

[1] See *Lancet*, October 14, 1899 (abstract).

[2] Wright, 'On the Pathology and Therapeutics of Scurvy,' Army Medical Reports, 1895. It must be pointed out that the reaction of the ash of foods still requires elucidation. I have not been able to find, for example, that meat leaves an acid-reacting ash.

CHAPTER XVII

WATER AND MINERAL WATERS

About two-thirds of the total weight of the body is made up of water. The importance of water as a tissue-builder and its right to rank as a true 'food' are at once apparent from this statement.

About 4½ pints of water are given off from the body every day in the various excreta and exhalations, and of this about one-sixth is actually formed in the tissues out of hydrogen and oxygen, the remainder being derived from the food and fluids consumed. If one reckons that half of the whole weight of solid food taken consists of water, then the amount required to be added to the diet in an actually fluid form would be approximately 2⅓ pints (about two breakfast-cupfuls and three tumblerfuls). Obviously, however, the exact amount must vary very greatly with external conditions, and especially with the amount of sweat produced.

The nature of the diet has also an important influence on the amount of water consumed. On this point some interesting observations have been made by Voit, examples of which are contained in the following table:

Food consumed.	*Water consumed.*	*Water in Fæces.*
800 grammes of bread	1,151 grammes.	212 grammes.
500 ,, of meat and 200 of fat..	760 ,,	25 ,,
500 ,, ,, 200 of starch	646 ,,	16 ,,
1,500 ,, of meat	1,238 ,,	10 ,,

It will be observed that, upon the whole, the amount of water consumed is proportionate to the amount contained in the fæces. Where, as in a bread diet, the fæces are rich in water, an increased amount of fluid is consumed in order to make up for the loss from the bowel. This fact is entirely opposed to the statement not infrequently made, that a diet mainly composed of vegetable ingredients tends to lessen thirst. On the other hand, if nitrogenous food, such as meat, is eaten in large quantities, the consumption of water must

also be increased, owing to the necessity for providing for the proper elimination of urea and other products of nitrogenous waste. For this reason the body tends to become richer in water if the diet is chiefly composed of fats and carbohydrates, and poorer in water if the food be rich in proteid. We have already seen that this increased wateriness of the body is one of the consequences of a purely vegetable diet.

EFFECTS OF AN INCREASE OR DIMINUTION OF WATER IN THE DIET.

If a litre of water be swallowed on an empty stomach, one finds that almost the whole of it has been excreted in the urine within the space of three hours. That this result is not due to mere dilution of the blood is shown by the fact that if normal salt solution be taken instead of water the result is precisely the same.[1] The real explanation would appear to be that the total volume of the circulating fluid in the body is a fairly fixed quantity, and is maintained so by some regulating mechanism, so that it is not possible permanently to increase it. Nor can the volume of the blood be much reduced by diminishing the amount of water consumed. It is probable that such an effect can only be produced for a very short time. Recent experiments have shown[2] that if the water of the diet be reduced by about 27 per cent. there is indeed evidence that the blood becomes more concentrated, for in one such case the solids of the plasma rose from 8·8 to 11·6 per cent., the number of red corpuscles from 4,800,000 to 5,580,000 per cubic millimetre, and the specific gravity of the serum from 1027·4 to 1033·4. At the same time the arterial tension and the volume of the pulse were diminished. It was found, however, that equilibrium was very readily established, so that in a subsequent experiment the results were much less pronounced. This equilibrium seems to be brought about by an interchange of fluid between the blood and the tissues. If the blood becomes more concentrated, water passes into it out of the tissues to make good the deficiency, so that the latter become drier. Hence it is that if the tissues become water-logged, as they do in cardiac dropsy, good results may be obtained by restricting the amount of fluid in the diet, for the tissues will then drain themselves into the bloodvessels. Conversely, if the blood be habitually overloaded with water, as it is apt to be, for example, in those who habitually

[1] See Falck, *Archiv. f. Physiol. Heilkunde*, xi. 125, 1852, and Schmaltz, *Deut. Archiv. f. Klin. Med.*, xlvii. 145, 1891.
[2] Dennig, *Zeit. f. Diät. und Physik. Therapie*, i. 281 and ii. 292, 1898.

consume large quantities of beer, some of the surplus passes out of the vascular area into the tissues, which then become abnormally watery. The tissues are therefore, in a sense, reservoirs of water, and it is to the rapid emptying or filling of these that sudden alterations in the weight of the body are usually to be ascribed. For example, in the experiment just mentioned, in which the fluids of the diet were reduced 27 per cent., the patient lost 8 per cent. of his weight within a week. It is important to bear this influence of water on the body weight in mind, for there is no doubt that the fluctuations which it brings about are often erroneously attributed to the loss or storage of solids such as fat. Much of the loss of weight in acute fevers, for instance, is certainly due to increased dryness of the body, and its very rapid restoration during convalescence is the result of a retention of water in the tissues. The same holds good for obesity. Those who have insisted upon the aid which a restriction of the fluids of the diet furnishes in reducing a patient's weight have too often forgotten that the reduction is not necessarily due to the removal of fat at all. But we shall return to this subject in discussing the dietetic treatment of obesity.

It has been stated that we are unable, by increasing or diminishing the amount of water in the diet, to bring about any *permanent* alteration in the volume of the blood. It must not be concluded from this that any regulation of the fluid consumed is entirely without effect in cases of disease affecting the cardio-vascular apparatus. Quite the contrary is the case. The mere temporary rise in the volume of blood to be driven round the circulation which the consumption of a large quantity of fluid brings about, and the increased labour which its excretion entails, may of themselves seriously hamper an already embarrassed heart; and for this reason the amount of water in the diet, in cases of advanced cardiac disease and dropsy, may often be greatly reduced with nothing but benefit to the patient. On the other hand, it must always be remembered that, if one reduces the consumption of fluid to the extent of increasing the viscosity of the blood, one increases thereby the resistance offered in the capillary circulation, and the increased strain thus thrown upon the heart may end by doing more harm than the restriction of the volume of the blood does good.

One may perhaps best avoid both dangers by seeing that the amount of fluid consumed is not only moderate in quantity, but is evenly distributed over the day, so that there is no period at which the total volume of the blood is unduly swelled.

It will be understood that very much the same remarks apply to

the treatment of aneurism. What we have to avoid in that disease is throwing any undue strain upon the weakened vessel walls, and that can best be done by taking care that the circulation is never flooded by the sudden access of a large quantity of extraneous fluid. For a similar reason it is often advisable to restrict the consumption of fluids after severe hæmorrhage, in spite of the great thirst of which the patient usually complains, for the vascular strain which any increase in volume of the circulating fluid must inevitably bring about may be quite sufficient to start the bleeding afresh.

Influence of Water on Digestion.

The first point which it is necessary to emphasize in this connection is that *water is not absorbed by the mucous membrane of the stomach at all.* This is certainly a surprising fact, but it has been incontestably established both by physiological experiment and by observations on patients suffering from obstruction at the outlet of the stomach.

When water enters the stomach, it begins to flow out into the intestine almost at once, the process going on in little gushes through the pylorus until all the water has escaped. Roughly speaking, one may assume that a pint of water will have entirely escaped from the stomach in the space of about three-quarters of an hour.[1] The precise rate of leaving, however, is very markedly influenced by temperature. Hot water escapes from the stomach much more rapidly than cold.[2] The heat increases powerfully the movements of the stomach walls, and at the same time seems to cause the pylorus to open, so favouring the escape of the contents. The stimulating effects which hot water exerts on gastric peristalsis render it a powerful aid to sluggish digestion, while the 'unlocking' of the pylorus which it brings about is probably the explanation of the almost instantaneous relief which it affords in many cases of 'cardialgia.'

The fact that water is exclusively absorbed in the intestine has important bearings on the treatment of patients suffering from dilated stomach. In the extreme form of that disease, when the stomach contents are quite unable to escape through the pylorus, the entrance of water into the blood is arrested, and the patient is the victim of a 'tissue thirst,' to which much of the emaciation and discomfort from which he suffers must be attributed. Not only is this so. The deficiency in the supply of water to the blood may go

[1] Moritz, *Münch. Med. Wochensch.*, No. 41, 816, 1894.
[2] Schüle, *Zeit. f. Klin. Med.*, 28, 461, 1895, and 29, 49, 1896.

so far that the proper excretion of waste products is interfered with, and toxic symptoms, such as coma or convulsions, may then supervene. In such cases there is an imperious necessity for getting water into the blood by some route other than the stomach, preferably *per rectum*.

The rapidity with which water passes through the stomach causes it to be a very dangerous vehicle of infection, for the hydrochloric acid of the gastric juice has no time to act upon any germs which it may contain. For this reason contaminated water is a more obnoxious carrier of disease that impure milk. All the greater, then, is the reason for insuring that our water-supply is above suspicion.

It is commonly said that the free consumption of water at meals is apt to delay digestion by diluting the gastric juice. This statement is not well grounded. Water is itself a slight, though unimportant, excitant of gastric secretion, and experiment has shown[1] that even in quantities of ½ litre (about a pint) it does not in any way affect the rapidity of digestion. Even 1 litre produces only slight slowing, while it requires quantities of 1½ litres (about 3 pints) to produce any marked effect.

On the other hand, it must be remembered that water may actually hasten the digestion of some foods by softening them and favouring their reduction to a state of pulp, while hot water is, as we have seen, a powerful stimulant of the stomach movements.

On the process of *absorption*, water does not seem to exercise any very marked effect, for even on a dry diet the solid constituents of the food entered the blood with their accustomed freedom (Dennig). Any influence which it may exert, however, is probably a favourable one.

Influence of Water on Metabolism.

The influence of water on the chemical processes of the body would seem to be very slight. It was formerly believed that an increased consumption of water was accompanied by an increased waste of the nitrogenous tissues. This is now regarded as an error. Any increased excretion of nitrogen which a free consumption of water entails is now ascribed, not to an increased breaking-down of the body substance, but to a washing-out of the tissues and the elimination of waste matters loitering in them.[2] This eliminative function of water is one of the first importance. It indicates the

[1] Fleischer, *Berliner Klin. Wochensch.*, No. 7, 1882.
[2] See R. O. Neumann, *Archiv. f. Hygiene*, xxxvi. 248, 1899.

necessity for a free supply of that fluid in such diseases as gout, diabetes, and fevers, and in cases in which the excretory power of the kidney is deteriorated.

Varieties of Water.

A good drinking water should have little or no colour, no odour, a pleasant, fresh taste, and should contain only a moderate amount of solid matter, 8½ grains per gallon being a good average. A tumblerful of ordinary London water contains only about one grain of solids. A wholesome water should contain very little organic matter, and that should be of vegetable origin, and if it has anything like a large proportion of chlorides it should be viewed with suspicion.

The amount of lime salts which drinking water contains is a mattei of some importance, and the relative merits of hard and soft water for drinking purposes have been much discussed. It has been maintained on the one hand that hard waters are apt to be productive in those who habitually consume them of such diseases as goître and stone, while on the other hand it has been said that soft waters may favour the development of rickets. It must be admitted that neither of these contentions is very well founded, but it may be granted that it is well that the water one drinks should not contain more than 1·5 grains of lime salts in every gallon, and that the sulphate of lime is more likely to be harmful than the carbonate, for in some susceptible persons its presence may excite dyspepsia and diarrhœa.

The fear that the use of soft water may lead to the development of rickets is quite groundless. When one remembers that even a hard water only contains about 0·002 grm. of lime in every 100 c.c., and that an infant requires about 0·32 grm. of lime daily, it will be evident that as a source of calcium for the bones water may be practically disregarded. On the other hand, there is no doubt that soft waters are more liable to become contaminated with lead than those which are richer in lime salts, and in that respect at least soft water may be a source of danger to health.

The dangers of **water as a source of infection**, owing to its contamination with the germs of disease, have already been mentioned, and one of the reasons for it pointed out. The avoidance of such contamination, and the provision of pure water on a large scale, is one of the most important duties of the Public Health Authorities in any community, but the methods by which these results are to be obtained hardly fall within the scope of this work. One is

frequently, however, asked for advice as to the domestic purification of water, and as to the best means of avoiding the risk of infection from it, especially during epidemics. The reply one should make to such inquiries is quite clear. The *only* reliable method of rendering water harmless is by boiling it. It may be objected that this gives the water a flat and insipid taste, but that objection can easily be overcome by subsequent aeration in a gazogene, or by simply shaking up the water with air in a stoppered bottle. The recent invention known by the name of the **Sparklets Process** is also a very simple and efficient method of aerating water, and so overcoming the flatness produced by boiling. For convenience in out-of-door use and when travelling it surpasses all other methods. The addition of toast, also, to boiled water communicates to the latter the flavour of some of the soluble ingredients of the toast, and has long been in use as a means of overcoming the flatness produced by boiling.

It may be asked whether filtration is not an efficient means of rendering water free from danger. The reply, I am afraid, must be in the negative. There is no filter, not even the Pasteur-Chamberland or Berkefeld, excellent though these are in many respects, which can be depended upon, in the hands of the ordinary householder, to render drinking water free from all risk. Boiling is the only efficient method.

Before leaving this subject, one must also warn the reader against the delusion so often cherished, that the addition of a little spirits, or even wine, to water can kill any germs that are in it, and so render it safe. That is not the case; the proportion of alcohol in the mixture is never high enough to be certain of killing the organisms.

Aerated and Mineral Waters.

Artificial aerated waters, which are now so familiar, were invented by the distinguished chemist Joseph Priestley, in the latter half of last century.[1] They are made by charging water with carbonic acid gas at high pressure, the gas being derived from the action of vitriol on chalk. The best varieties in this country come from Belfast. Ordinary bottles of aerated water contain 3 or 4 volumes of carbonic acid gas to 1 volume of water; syphons contain more. There is no doubt that this proportion is needlessly high, and has the effect of causing such violent ebullition when the bottle is opened

[1] 'Directions for Impregnating Water with Fixed Air, in order to Communicate to it the Peculiar Spirit and Virtues of Pyrmont Water and other Mineral Waters of a Similar Nature,' Joseph Priestley, London, 1772.

that some of the contents are apt to be lost during the escape of the surplus gas. The only advantage attendant upon this process is that the gas, as it passes off, withdraws from the water a considerable amount of heat, so that aerated waters are always cooler to the taste than ordinary water kept under the same conditions.

The varieties of artificial aerated waters which call for mention are as follows:

1. *Ordinary Water impregnated with Carbonic Acid Gas.*—The best makers obtain the water from artesian wells, so that it is of great purity. Ordinary water so impregnated is often, but erroneously, described as 'soda-water.' As soda is sometimes entirely absent, it is better to describe it simply as 'carbonated water.'

2. *Aerated Distilled Water.*—In this case the water is distilled prior to being charged with gas. It is therefore entirely free from mineral matter and from all impurities. Examples of such water are sold under the names of 'Puralis' and 'Salutaris.'

3. *Water to which Various Chemical Salts have been added, e.g.:*

Soda water, containing 3 to 5 grains of bicarbonate of soda to the bottle.
Medicinal soda water, containing 15 grains of bicarbonate of soda ditto.
Potash water, containing 15 grains of bicarbonate of potash ditto.
Magnesia water, containing 12 grains of carbonate of magnesia ditto.
Carrara water, containing 5 grains of lime ditto.
Lithia water, containing 3 to 5 grains of carbonate of lithia ditto.

4. *Imitations of Various Natural Mineral Waters.*—One of the best examples of these is seltzer-water, which is intended to be a substitute for the natural water obtained from the Selters spring. Its ingredients are common salt, bicarbonate of soda, carbonate of magnesia, and hydrochloric acid. By the interaction of these constituents an aerated water is produced which 'gives a good imitation of the peculiar mellowness of genuine seltzer.' An analysis of Schweppe's seltzer showed it to contain 1·13 grains of mineral matter per imperial pint, or 0·620 grain per bottle. A tumblerful had an acid-neutralizing power equal to that of 37½ c.c. of decinormal soda solution.

5. *Sweetened and Flavoured Mineral Waters.*—This is the large and popular group which includes lemonade, ginger-beer, *et hoc genus omne.* The basis of their composition is water sweetened with cane-sugar, and rendered tart by the addition of an acid, then flavoured in any way desired, and finally charged with carbonic acid gas.

A bottle of such water contains about 1 ounce of sugar (equal to five or six ordinary lumps). Unless the water is sold as a genuine 'fruit product' the acid added is only exceptionally citric or tartaric; far more often one finds that a mineral acid is used, most

commonly phosphoric, in the form of so-called 'phospho-lactic' or 'phospho-citric' acid. Some makers employ acetic acid. If citric or tartaric acid is used, the amount added is about 10 grains per bottle, and, as a rule, the acidity of a bottle of ordinary mineral water of this class may be reckoned as about equal to that of a tablespoonful of good vinegar.

The following recipes for making mineral waters are taken from the 'Mineral Water Maker's Manual' (1896), and will serve to show the constituents of some of these products:

Lemonade.

Plain syrup,[1] 1 gallon.
Lemon tincture, 4 ounces.
Acetic acid, 4 to 5 ounces.
1 to 1½ ounces to the bottle.

Orangeade.

Plain syrup, 1 gallon.
Orange tincture, 4 to 6 ounces.
Acetic acid, 4 ounces.
1 to 1½ ounces to the bottle.

Ginger-beer.

Plain syrup, 3 quarts.
Boiling water, 1 quart.
Oil of lemons, 24 minims.
Acetic acid, 4 fluid ounces.
Tincture of ginger, *q.s.*
1 to 1½ ounces to the bottle.

Gingerade.

Plain syrup, 1 gallon.
Tincture of ginger, 4 ounces.
Acetic acid, 4 ounces.
Bitter orange tincture, *q.s.*
1 to 1½ ounces to the bottle.

Ginger-ale.

Plain syrup, 1 gallon.
Compound tincture of ginger, 4 ounces.
(Or tincture of capsicum, 1 ounce.)
Acetic acid, 4 ounces.
Sugar colouring, ½ ounce.
1 to 1½ ounces to the bottle.

It will be observed that 'lemonade' and 'orangeade' have very little to do with the fruits from which they derive their names. The term 'ginger-beer' or 'ginger-ale' is even more ambiguous. The article so named may have nothing to do with ginger at all, for the requisite degree of sharpness is usually obtained by aid of tincture of capsicum.

Genuine fermented ginger-beer ('stone ginger') is a very different product. The following are its ingredients:

Water	21 gallons.
Sugar	21 pounds.
Bruised ginger	1½ pounds.
Tartaric acid	6 ounces.
Gum arabic	1 pound.
Oil of lemon	¼ ounce.
Yeast	½ pint.

As the result of fermentation it usually contains at least 2 per cent. of alcohol, sometimes considerably more.

[1] 10 pounds of sugar to 1½ gallons of water.

Natural Mineral Waters.

These are obtained from natural springs, and the majority of them are impregnated with carbonic acid gas. The mineral matters which they contain are very various, but the most abundant are common salt and alkaline salts of soda or lime. For ordinary table use a water must not contain more than 1 per cent. of mineral matter, for above that one begins to get the specific effect of its salts.

The following table contains a description of the natural table waters most largely used in this country, and the results which were obtained from a comparison of their respective acid-neutralizing powers:

Water.	Mineral Matter in an Imperial Pint (in Grms.).	Mineral Matter in a Bottle (in Grms.).	Acid-neutralizing Power of 250 c c. (=1 tumblerful), expressed in c.c. of Decinormal Caustic Soda.	General Description and Remarks.
Apollinaris ..	2·27	1·40	91·8 c.c. $\frac{N}{10}$NaOH	From spring in valley of Ahr (Rhenish Prussia). An alkaline, highly aerated, and slightly chlorinated water. Chief constituents: sodium chloride and carbonates of soda and lime.
Rosbach ..	1·05	0·61	29·3 c.c.	From spring near Homburg. Mildly alkaline; well aerated; lightly mineralized; containing about 82 grains of sodium chloride and 38 grains of earthy carbonates in a gallon.
Johannis ..	1·58	0·95	31·8 c.c.	Produced at Johannis springs (Zollhaus in Nassau). Mildly alkaline and well aerated. Chief salts are carbonates of lime, soda, and a small amount of sodium chloride. A lithiated Johannis is made from this, containing 1 grain of bicarbonate of lithia per bottle.
Kronthal (blue label)	2·47	1·59	11·5 c.c.	From Kronthal springs, in the Taunus district, Germany. A mildly alkaline and well-aerated table water, with 189 grains sodium chloride, 57·4 of calcium carbonate, and 14 of sodium carbonate per gallon.
Kronthal (red label)	3·14	1·94	14·2 c.c.	Similar to the above, but containing more mineral matter, and relatively more chloride and less carbonates. Apt to be mildly aperient.
Kronthal (green label)	3·04	1·74	33·5 c.c.	A chalybeate water, well aerated, mildly alkaline, containing a considerable amount of iron.

Less used are:

Vichy (État), with 8 grammes solids per litre (5 grammes bicarbonate of soda). It has a high acid-neutralizing power, 250 c.c. = 268 c.c. decinormal acid, but cannot be regarded as a water adapted for use in health.

St. Galmier, which is largely used in France, has 2·8 grammes solids per litre, chiefly earthy bicarbonates.

Contrexéville (Pavillon) has 2·3 grammes solids of a similar nature, and is only slightly gaseous.

Sparkling Malvern is a pure natural water derived from the Malvern springs. It has 118 grains of solids per gallon (0·866 gramme per bottle), including 61 grains of sodium carbonate and 36 of sodium chloride.

Seltzer (Nieder-Selters, in Nassau) has 3·6 grammes solids per litre, consisting of 2·24 of sodium chloride and 1·3 of carbonates.

Adonis is a mildly alkaline water, containing 4½ grains sodium bicarbonate per pint. It is soft and well aerated, and is derived from springs situated in the Belgian Ardennes.

Uses of Mineral Waters.

What dietetic advantages are obtained from the impregnation of water with carbonic acid gas? Apart from the pleasant, sharp taste which such water possesses, one finds that carbonic acid gas is an undoubted aid to digestion. Indeed, it may be said that the mineral waters stand alone among beverages, in that they actually promote the *chemical* processes of digestion. Not only is this the case; carbonic acid acts as a stimulant to the movements of the stomach, and so aids the mechanical processes of digestion also, while the bubbling up of the gas through the stomach contents doubtless facilitates their disintegration.

There are cases, however, in which such waters should be avoided. Carbonic acid gas is rapidly absorbed from the stomach into the blood, and where that fluid already contains an excess of the gas, as it does in cyanosis, it may be well not to run the risk of adding to it. The mechanical distension of the stomach, too, which the escape of the gas induces may be harmful in dilatation of that organ, and in other cases may hamper a weakened heart by causing the fundus of the stomach to press up against it.

Unfortunately, it cannot be justly claimed for the aerated waters that they are always sterile. Carbonic acid gas is *not* fatal to organisms, with the exception, perhaps, of the cholera bacillus. On the other hand, the mineral waters supplied by the best makers are usually prepared from water obtained from artesian wells, and on that account are likely to be free from the germs of disease. The distilled aerated waters are also beyond reproach in this respect, but they must be used with caution, for there is reason to believe that distilled water may have injurious local effects in the stomach, and lead to nausea and vomiting by destroying its surface epithelium.

The question of **natural *versus* artificial mineral waters** must be

decided entirely in favour of the former. For one thing, the natural waters do not contain any excess of gas, and a larger proportion of what they do contain is present in a combined form than is the case with the artificial waters. Hence their gas is given off more slowly, and they remain longer brisk, and are less apt to lead to sudden distension of the stomach. The following experiment bears this out[1]:

	Natural Water.	*Artificial Water.*	
Gas evolved ..	480 c.c.	760 c.c.	Bottle opened and exposed for half an hour.
Gas remaining ..	1,010 c.c.	723 c.c.	
Total ..	1,490 c.c.	1,483 c.c.	

There is also reason to believe that the effects of the salts in natural mineral waters are such as cannot be obtained from any artificial imitation of them. The reasons for this have been discussed by Koeppe.[2] He attributes it to the fact that the natural waters contain *traces* of many salts which are not present at all in the artificial waters, and which are yet not without effect on the body. Being formed under pressure, too, the natural waters contain double salts, the physical effects of which are not comparable to each salt taken separately, for each salt has its own partial pressure, while for any given degree of concentration one finds fewer dissociated 'ions.' This is not without influence on the physical processes of osmosis, and as a matter of fact it has been found that more mineral matter is absorbed in a given time by the intestine of a dog from a natural than from an artificial water.

The slight alkalinity of some of these waters renders them useful additions to the more acid wines, for the inhibitory action of the latter on the saliva is thereby corrected. For this purpose there is no better water than Apollinaris, though the stronger varieties of soda-water are an efficient, though less agreeable, substitute.

The sweetened mineral waters, such as lemonade, are apt to disagree with the stomach and produce 'acidity,' both by reason of the not inconsiderable amount of acid which they contain, and also from the action of their sugar on the secretory processes in the stomach, and perhaps also by fermentation. On the other hand, it must be remembered that such beverages are by no means devoid of nutritive value, for a bottle of one of them contains enough sugar to yield nearly 115 Calories of energy to the body; and their refreshing influence in fatigue may also be explained by reference to the value of sugar as a food in exhaustion (see p. 272).

[1] Analytical Reports, *Lancet*, August 8, 1891.
[2] See footnote, p. 277, and Dr. Brasch, *Zeit. f. Diät. und Physik. Therapie*, iii. p. 688, 1900.

CHAPTER XVIII

TEA, COFFEE, AND COCOA

In dealing with these beverages, it will be convenient to take up the history, mode of manufacture, and chemistry of each of them separately, and then to consider their action on digestion and their uses in the diet together.

Tea.[1]

1. *History.*—Tea was introduced into Europe by the Dutch East India Company in the year 1610. As its price was at first ten guineas a pound, it can be readily imagined that it grew but slowly in popularity, and even in 1660 we find Pepys writing in his Diary: 'I sent for a cup of tee, a China drink, *of which I had never drank before.*' By the beginning of this century the annual consumption had risen to 1¼ pounds per head of the population, and now, 100 years later, it amounts to fully 6 pounds per head. In Great Britain, indeed, we consume more than all the European countries put together, about 600,000 pounds of tea, or 4,000,000 gallons of the beverage, being used daily. It is only in Australia, where tea is so largely used in the Bush, that the consumption surpasses that of this country, amounting as it does to 9 pounds per head of the population annually.

Up to the year 1862 nearly all our tea was obtained from China, the imports from that country reaching their maximum in 1879. Since that time the consumption of China teas has rapidly declined, their place being taken by Indian tea, and, since 1880, by teas grown in Ceylon. The proportion of China tea is now less than 12 per cent. of the total import.

2. *Mode of Manufacture.*—Tea was originally obtained from the

[1] I am indebted for much valuable information on the subject of tea to the following, among other publications: Bannister's Cantor Lectures, 1895; A. G. Stantor, *Journal of the Society of Arts*, January 25, 1890; Prescott, *Popular Science Monthly*, xx. 359, 1882.

leaves of the *Thea chinensis* and *Thea assamica*, both of the Camellia order; but many hybrids are now used for tea production. The plant 'flushes,' or sends out young shoots, four times in the year, and is 'picked' at each 'flush.' In China and Japan the best tea is obtained from the first 'flushing,' but in India and Ceylon this is not the case.

The **varieties of tea** are named according to the different leaves from which they are produced (Fig. 28). The young shoot has two small leaves at its tip which contain least fibre and most juice, and therefore produce the finest sort of tea. In India and Ceylon, tea produced from these leaves is called 'flowery' and 'orange' 'Pekoe,' or, if the leaves are still smaller, 'broken Pekoe.' The tea produced from a somewhat larger leaf just below this is called 'Pekoe'; the next largest leaves produce 'Souchong'; the leaves below that, 'Congou' (though these are not often picked now); while a still coarser leaf near the base of the shoot used to yield 'Bohea,' which has now, however, almost disappeared from commerce.[1]

FIG. 28.—YOUNG SHOOT OF TEA PLANT (AFTER MONEY).

a, Flowery Pekoe; *b*, Orange Pekoe; *c*, Pekoe; *d*, Souchong (first); *e*, Souchong (second); *f*, Congou; *H*, Bohea; *a* and *b* (mixed), Pekoe; *a*, *b*, *c*, *d*, and *e*, Pekoe-Souchong.

In China a slightly different nomenclature is used, the whole end of the young shoot, with its cluster of leaves, going to form 'Pekoe,' while the leaves below that are used for the production of 'Souchong.'

It should be noted also that the term 'Congou' is often applied in the retail trade to blends, while 'Pekoes' and 'Souchongs' are unblended teas.

The treatment of the leaves after they are picked varies according as black or green tea is to be produced.

For the production of **black tea**, the leaves are withered in the sun, then rolled till they become soft and 'mashy,' the object of

[1] 'Pekoe' is derived from 'poco,' the hair or down on the young buds; 'Souchong' means 'little sprouts'; and 'Congou' signifies labour, from the care required in the subsequent treatment of the leaves.

this being to break up the fibre and cells of the leaf, and liberate the constituents, so that they are afterwards more easily extracted, and then made into balls and allowed to ferment. During the process of fermentation, some of the tannic acid in the leaves appears to be oxidized and converted into less soluble forms, while more essential oils seem to be produced, and a certain amount of bitterness developed. After fermentation is complete, the leaves are sun-dried, and then 'fired' in a furnace.

For the production of **green tea**, the fresh leaves are withered in hot pans at a temperature of 160° F. (Chinese method), or steamed (Japanese method); then rolled to break them up and liberate their juices; then withered again, sweated in bags, and finally submitted to a prolonged and slow roasting.

It will be observed that the chief difference between black and green tea is that the former is fermented, while the latter is not; and one of the main results of fermentation seems to be to render the tannic acid less soluble, so that, as we shall shortly see, an infusion of green tea contains more tannin than an nfusion of black.

In the old days a good deal of so-called green tea was really made in the same way as black, and subsequently 'faced' with Prussian blue or indigo to give it the proper colour; but I am informed that this does not take place now to any important extent.

We have seen that the quality of teas varies with the age of the leaf from which they are prepared, the younger leaves yielding the finest tea. Apart from this cause of variation, teas show marked differences according to the country and district in which they are produced.

Chinese teas have the most delicate flavour of any, but are rather lacking in 'body'; they are also devoid of any marked astringency.

Indian teas, and especially those produced in Assam, have the greatest degree of 'body' and astringency. This makes them powerful teas, suited rather for blending with milder varieties than for drinking alone.

Ceylon teas have plenty of body, and a rich and peculiar flavour, but have not so much strength or pungency as the Indian varieties.

According to the district in which they are produced, **Chinese black teas** may be divided into:

1. Monings, from North China, with a small and delicate leaf and a peculiar malty flavour.

2. Kaisows, from South China, the so-called red-leaf teas, because the original teas grown in this district had a reddish leaf.

3. Oolongs, from Formosa, pungent and slightly bitter, yielding a pale infusion, and chiefly used for purposes of blending.

4. Scented orange Pekoe and scented Caper come from the Canton district, and yield a pale, strong infusion with an aromatic flavour, for which reason they are used to give bouquet to blends. Caper is really an unfermented tea, highly fired, and standing intermediate between the black and green varieties.

Of **Indian black teas**, those from the Darjeeling district are best, being less rough and astringent than those of Assam, and well adapted for drinking alone. It should be remembered that most black teas in the market are really blends of Indian, Ceylon and China in different proportions.

Most **green teas** come from North China and Japan, the latter being the best. Very little is produced in India.

The chief varieties of green tea are Young Hyson[1] and Gunpowder, the former corresponding to a Souchong among black teas, and the latter to Congou.

In judging a tea, professional tea-tasters are guided by the nature of the liquor and the characters of the infused leaves or 'out-turn.'

The infusion should be of a reddish-golden colour, pungent in flavour, but not too bitter or astringent, and not 'thin' or 'hard.'

The infused leaves should be of a bright coppery tint, and evenly extracted, so that some do not look darker than others; they should be uniform in size, and after five minutes' infusion should not be completely unrolled. There should not be too much stalk mixed with the leaves.

3. *Chemical Composition of Tea.*—The following analyses of two typical varieties of tea are given by Bannister:[2]

	Congou, at 2s. 10d. (Typical Black Tea).	*Young Hyson, at 3s. (a Typical Green Tea).*
Water	8·20	5·96
Caffeine	3·24	2·33
Albumin (insoluble)	17·20	16·83
,, (soluble)	0·70	0·80
Alcoholic extract	6·79	7·05
Dextrin	—	0·50
Pectin and pectic acid	2·60	3·22
Tannic acid	16·40	27·14
Chlorophyll and resin	4·60	4·20
Cellulose	34·0	25·90
Ash	6·27	6·07

[1] Young Hyson = Yu-Chien, 'before the rains.'
[2] Cantor Lectures, 1890.

Of these ingredients, the most important are the alkaloid **caffeine** (also called theine) and **tannic acid**; for these, along with a small proportion of volatile oil ($\frac{1}{2}$ per cent.), are the ingredients to which the chief effects of tea on the body are due. The importance of the caffeine and tannic acid is so great that it may be well to bring forward some further and very exact estimations of these ingredients in different teas which were made by Allen :[1]

Description of Tea.	*Tannic Acid.*	*Caffeine.*
Ceylon, whole leaf (Pekoe)	13·01 per cent.	3·85 per cent.
,, broken leaf	12·31 ,,	4·03 ,,
Assam, whole leaf (Pekoe)	10·08 ,,	4·02 ,,
,, broken leaf	11·33 ,,	4·02 ,,
Java Pekoe	12·93 ,,	3·75 ,,
Kaisow, red leaf	11·35 ,,	3·41 ,,
Moning, black leaf	11·76 ,,	3·74 ,,
Moyune Gunpowder	12·95 ,,	2·89 ,,
Natal Pekoe Souchong	9·90 ,,	3·08 ,,

Indian and Ceylon teas are richer in all the chief ingredients (caffeine, tannic acid, and volatile oil) than China teas. Green tea is richer in tannic acid than black, but the amount of caffeine in the two is almost the same. The following table[2] (from analyses by Mr. Y. Kozai in Japan) shows the **difference in composition between green and black tea** produced from the same leaves:

	Original Leaves.[3] *Per cent.*	*Green Tea. Per cent.*	*Black Tea. Per cent.*
Crude proteid	37·35	37·43	38·90
,, fibre	10·44	10·06	10·07
Ethereal extract	6·49	5·52	5·82
Other nitrogen-free extract	27·86	31·43	35·39
Ash	4·97	4·92	4·93
Caffeine	3·30	3·20	3·30
Tannic acid[4]	12·91	10·64	4·89
Soluble in hot water	50·97	53·74	47·23
Total nitrogen	5·97	5·99	6·22
Albuminoid nitrogen	4·11	3·94	4·11
Caffeine ,, ...	0·96	0·93	0·96
Amido ,, ...	0·91	1·13	1·16

The table shows quite clearly the reduction in tannic acid which the process of fermentation brings about in black tea.

On an average, one may say that the proportions of the active ingredients in ordinary teas are as follows:

Caffeine	2 to 4 per cent.
Tannic acid	10 ,, 12 ,,
Volatile oil	$\frac{1}{2}$,,

[1] 'Commercial Organic Analysis,' vol. iii., part ii.
[2] See United States Department of Agriculture, Division of Chemistry, Bull. 13, 1892.
[3] Dried at 105° C.
[4] As gallo-tannic acid.

The **composition of the infusion** is of much greater practical importance than that of the leaves from which it is made.

If tea is infused for five minutes in the usual way, about 25 per cent. of the weight of the leaf goes into solution. In making an ordinary teacupful of tea (about 150 c.c.), 5 grammes of dried leaf are usually employed, and a cupful of such tea contains in solution about 15 grains of solid matter. The bulk of this is made up of gummy matters, extractives, etc., but the most important ingredients are the caffeine, tannic acid, and volatile oil.

The caffeine is so soluble that it is practically all dissolved out of the leaf immediately infusion has begun. With tannic acid this is not the case. There is certainly less tannic acid after three minutes' infusion than after five, and less after five than after ten; but beyond that one does not find much increase, for by that time practically the whole of the soluble matters have been extracted from the leaf. The following experiments bear upon this point:

Hughes[1] found the following **proportions of tannic acid extracted in different times**:

	Five Minutes' Infusion.	*Thirty Minutes' Infusion.*
Assam	10·35 per cent.	14·76 per cent.
Ceylon	8·60 ,,	10·88 ,,
China	7·80 ,,	9·40 ,,

Hale White[2] found:

	Three Minutes' Infusion.	*Fifteen Minutes' Infusion.*
Finest Assam	11·30 per cent.	17·73 per cent.
,, China	7·77 ,,	7·97 ,,
Common Congou ..	9·37 ,,	11·15 ,,

(The figures represent percentage of tannic acid in weight of leaf used.)

The following results were got by Dittman:

		Caffeine. Per cent.	*Tannic Acid. Per cent.*
China tea (8 samples)	5 minutes' infusion	2·58	3·06
	10 ,, ,, ...	2·79	3·78
Ceylon ,, (6 ,,)	5 ,, ,, ...	3·15	5·87
	10 ,, ,, ...	3·29	7·30
Indian ,, (12 ,,)	5 ,, ,, ...	3·63	6·77
	10 ,, ,, ...	3·73	8·09

It will be observed here that the proportion of tannic acid is much more affected by the length of infusion than that of caffeine.

Finally, one may quote the experiments of Green,[3] in which 420 c.c. of boiling distilled water were poured on 3½ grammes of tea, and infusion carried on under a cosy for from five to forty minutes,

[1] *Journal of Society of Arts*, January 25, 1895.
[2] *Brit. Med. Journ.*, January 12, 1889.
[3] Thorpe's 'Dictionary of Chemistry.'

with the following results as regards the composition of the beverage:

	Five Minutes' Infusion. Per cent.	Ten Minutes' Infusion. Per cent.	Twenty Minutes' Infusion. Per cent.	Forty Minutes' Infusion. Per cent.
Extract	21·7	25·3	26·8	28·1
Caffeine	1·1	1·3	1·16	
Tannic acid	6·8	8·5	11·7	16·3
Nitrogen	1·11	1·16	1·11	1·04
Ash	3·52	4·09	4·15	4·48

All these experiments agree in showing that the longer tea is infused the higher is the proportion of tannic acid dissolved out, while the proportion of caffeine, on the other hand, is but little affected. The practical inference from this is that, if one wishes to avoid having much tannin in tea, one should infuse it for as short a time as possible.

The writer has made a number of experiments with the view of determining the amount of caffeine and tannic acid present in an ordinary teacupful of tea infused in the usual way. The results are contained in the following tables:

CAFFEINE IN TEAS.[1]

Tea.	*Caffeine in Grammes per 150 c.c.*	*Grains per Teacup.*
Ceylon Pekoe	0·0787	1·21
Fine Darjeeling	0·0751	1·05
Common Congou	0·0745	1·14
Moyune Gunpowder (green) ..	0·0645	0·99
Imperial Gunpowder	0·0590	0·90
Household blend	0·0580	0·89
Young Hyson	0·0547	0·84
Fine Moning	0·0510	0·78
Fine Assam	0·0475	0·73

TANNIN IN TEAS.[2]

Tea.	*Tannin as Gallo-tannic Acid per 150 c.c. of Infusion.*	*Grains per Teacup.*
Moyune Gunpowder	0·273	4·20
Young Hyson	0·242	3·72
Imperial Gunpowder	0·227	3·49
Ordinary black blend	0·173	2·66
Fine Darjeeling	0·168	2·58
Good black blend	0·168	2·58
Ceylon Pekoe	0·142	2·18
Lapseng Souchong	0·087	1·33
Fine Assam	0·080	1·23
Fine Moning	0·058	0·89

[1] Eight grammes of dry leaf were infused with 300 c.c. boiling water for five minutes. The caffeine was estimated by Allen's method.

[2] Eight grammes of the dry leaf were infused for five minutes in 300 c.c. of water, and the tannin estimated by Procter's modification of Löwenthal's process.

As a rule, one may say that a teacupful of tea of ordinary strength infused for five minutes contains about 1 grain of caffeine, and twice or three times as much tannic acid.

It may be well to give some practical **rules for the proper method of making tea** based on the facts as to its chemistry which we have just been considering. This is all the more important as it is comparatively rare to get a really good cup of tea, in spite of the popularity of the beverage. It must be admitted, too, that the fault lies oftener with the method of infusion than with the quality of the original leaf employed.

And, firstly, the tea should really be *infused*, not boiled or stewed, as is so often the case. The character of the water is of the first importance. The Chinese rule is, 'Take the water from a running stream; that from hill springs is best, river water is the next, and well water is the worst.' The meaning of this is that the water should be well aerated. Prolonged boiling makes it flat by driving off the dissolved air. Hence, the water should have just freshly come to the boil. If it is already flat, it is a good plan to pour it into a jug from a height, for this causes it to take up some air again.[1]

The water should not be too hard, for the presence of lime salts seems to interfere with the extraction of some of the constituents of the leaf. If only hard water is obtainable, it is a good plan to add a pinch of soda to the teapot. Water which is too soft is also bad, for it seems to extract a bitter principle from the leaf. Moderately hard water, therefore, is the ideal to be aimed at.

The quantity of leaf infused demands some attention. The domestic rule of 'a teaspoonful for each person and one for the pot' is an uncertain one, for the weight of a spoonful of tea is a very variable[2] quantity, depending as it does very much on the tightness with which the leaf is rolled.

Tea-tasters use the weight of a new sixpence (43½ grains) to 3½ ounces of water, and this, which is a somewhat smaller proportion of tea than that given by the domestic rule, yields a more satisfactory though weaker infusion. It must be remembered, however, that the popular taste is for a strong beverage with a good deal of 'body.'[3]

[1] The Chinese directions for preparing the water are as follows: 'The fire must be lively and clear, but the water must not be boiled too hastily. At first it begins to sparkle like crabs' eyes, then somewhat like fishes' eyes, and lastly it boils up like pearls innumerable, springing and waving about.'

[2] The weight of a caddy spoonful varies from 39 to 87 grains (Smith).

[3] For the economical preparation of good tea the thorough crushing of the leaf is of great importance, so that its ingredients may readily be extracted. The

The water, as we have seen, should be first brought to the boil, and the teapot should be thoroughly heated, so that the temperature may be maintained: for it is only at the boiling-point that some of the volatile constituents of the leaf, to which the beverage owes its aroma, can be properly extracted.

Infusion should be of limited duration—not more than four or five minutes, for prolonged treatment extracts too much tannic acid, and withdraws from the leaf also bitter substances which are better left behind. In addition to this, prolonged infusion dissipates the volatile oil to which much of the fragrance of a good cup of tea is due. The use of a 'cosy' during infusion does no harm, but whenever the process is completed the liquor should be poured off into another hot teapot, which may then be kept covered if desired.

The addition of milk or cream, though an outrage in the eyes of connoisseurs, is to be commended on hygienic grounds, for the albuminous matter of the milk tends to throw down some of the tannic acid of the tea in an insoluble form. Sugar does not in any way increase—indeed, it may detract from—the healthfulness of the beverage, but adds considerably to its nutritive value.

All second brews should be avoided, for a single infusion is sufficient to remove from the leaves all the useful constituents of the beverage.

Coffee.

Coffee was introduced into this country in the year 1652 by a certain Mr. Daniel Edwards, a retired Smyrna merchant, who set up his Greek servant in a coffee-house, the first of its kind in London, in St. Michael's Alley, Cornhill. As a beverage it has never attained the popularity with us that it has won on the Continent, for at the present day we consume less than a pound of it per head of the population annually, whereas in Holland the consumption amounts to 21 pounds. This may be explained partly, perhaps, by the fact that we do not know how to make coffee, but mainly from its great expense when compared with its principal rival, tea.

Coffee is derived from the *Caffœa arabica*, originally produced, as the name implies, in Arabia, but now cultivated in many tropical countries. The plant produces three harvests annually, the fruit resembling a cherry, in which the 'coffee-bean' corresponds to the stone. The bean consists of two halves placed face to face and

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powdered tea of Japan is ideal in this respect, and in this country the 'tea tabloids' recently introduced are deserving of a word of praise for the same reason.

enclosed in a husk. The pulp is softened by fermentation and removed, and the beans, still enclosed in their husk, are dried in the air. The husk is separated by rolling, and the beans are then separated from the delicate parchment-like skin which covers them, and assorted according to size.

Several **varieties of bean** are found on the market, the chief being as follows :[1]

1. *Mocha.*—The genuine beans of this, the finest sort of coffee, are derived from Arabia Felix, but much so-called Mocha coffee is really produced elsewhere, chiefly, perhaps, in Guatemala. Two varieties are met with, 'long berry' and 'short berry.' The former are grayish-yellow in colour, and give a rich, mellow liquor. The latter are pale greenish-yellow, and give a clearer and more delicate infusion (Bannister).

2. *Mysore.*—Here again the name is apt to mislead, for the majority of coffees of this name come from Java and Ceylon. The berry is bluish-gray in colour and yields a pure, strong and clear liquor.

3. *Ceylon Plantation.*—The berry is of a pale greenish tint, and yields a clear beverage of full but smooth flavour and fair body. This coffee is largely used for blending.

4. *Costa Rica.*—A bluish-gray berry yielding a strong but rather coarse liquor.

5. *Java.*—A very fine coffee, with large, pale, oblong berries yielding a strong, clear liquor.

6. *Brazil.*—A coffee of peculiar flavour, used chiefly for mixing with other varieties.

In order to prepare the beverage, the berries must first be roasted. The **composition of raw and roasted coffee** is thus contrasted by Bannister:

	Mocha.		East Indian.	
	Raw.	Roasted.	Raw.	Roasted.
Caffeine	1·08	0·82	1·11	1·05
Saccharine matter	9·55	0·43	8·90	0·41
Caffeic acids	8·46	4·74	9·58	4·52
Alcoholic extract (nitrogenous and colouring matters) ..	6·90	14·14	4·31	12·67
Fat and oil	12·60	13·59	11·81	13·41
Legumin	9·87	11·23	11·23	13·13
Dextrin	0·87	1·24	0·84	1·38
Cellulose and insoluble colouring matter	37·95	48·62	38·6	47·42
Ash	3·74	4·56	3·98	4·88
Moisture	8·98	0·63	9·64	1·13

[1] Bannister's Cantor Lectures, 1890

The chief physical change which results from roasting is that the berries are rendered brittle and can now be ground. Chemically, one finds that they lose from 13 to 20 per cent. of their weight, the loss consisting in nearly equal parts of moisture and organic matter. The lost organic matter includes about 21 per cent. of the total caffeine and 10 per cent. of the fat.[1] If the coffee is 'over-roasted,' the loss of caffeine may be considerably greater.

The most important substance *produced* in the coffee by roasting is an oil, **caffeol**, to which the aroma of roasted coffee is due, and the fragrance of which is so powerful that one drop is said to be sufficient to scent a whole room.

Composition of the Infusion.

From 25 to 35 per cent. of the coffee used in making the infusion goes into solution. This percentage of solubility is about the same as that of tea, but seeing that a much larger quantity of coffee is taken than of tea, the amount of solids per cup is considerably higher in the former than in the latter beverage. If 2 ounces be used to make a pint, a teacupful of the beverage will contain in solution about 4·2 grammes of solids, of which 0·65 is mineral matter. This is supposing the coffee to be filtered. As ordinarily drunk, some suspended matter must also be included.

An analysis which I have made of coffee of the above strength, showed the presence of 1·7 grains of caffeine per teacupful, and 3·24 grains of tannic acid.[2] According to this result, a cup of black coffee contains very much the same amount of caffeine and tannic acid as an equal quantity of tea. A breakfast-cupful of *café au lait* is composed of about 1 part of black coffee to 3 of milk, and will not, therefore, contain more of the alkaloid than a teacupful of tea.

French coffee demands a special word of mention. It usually contains more or less chicory, and sometimes also some burnt sugar. Chicory is the root of the wild endive, kiln-dried and broken into fragments. The process of drying converts its sugar, of which it may have 10 to 18 per cent., into caramel. There is no reason to believe that chicory is in any way injurious to health, but 1 pound of it is equal in colouring power to 2·8 pounds of coffee, and as a pound of chicory costs 3½d., while a pound of coffee costs about 1s. 5d., it is evident that 3½d. worth of the former is equal, as far as the mere appearance of the beverage goes, to 3s. 11d. worth of the latter. Hence the great temptation to adulterate coffee with chicory, a process which has done much to discourage the consumption of coffee in this country. As a rule, French coffee contains about one-

[1] *Analyst*, p. 287, 1897

[2] Reckoned as gallo-tannic.

third of its weight of chicory, but sometimes the proportion may be as high as 80 per cent., or even more.

Coffee-making.

The secret of having good coffee is to make it *strong* and to make it *hot*. We mostly fail in this country by not using enough. Two ounces to the pint is the smallest proportion which will give a good result. It is important that the coffee should be freshly roasted, for its fragrance is quickly dissipated on keeping, and in roasting one must see that the beans are of the same size; otherwise they will be unequally fired. For this reason mixing should be carried out after roasting, and not before. Care also must be taken that the grinder is quite clean, for if any stale coffee is left in it the whole may be spoilt. The water should be just boiling, and infusion may be carried out either in a jug or in a porcelain percolator. For breakfast coffee a mixture of coffees—*e.g.*, half and half Mocha and Plantation—may be used, and the addition of a little ground chicory is liked by some, but for black coffee the latter should always be omitted. Three parts of milk to one of coffeé is about the proper proportion for *café au lait.*

Cocoa.

Cocoa was first brought to Europe from Mexico by Columbus in the year 1520. It was known at that time as 'cacao,' but the name got changed with the lapse of time. Although introduced considerably earlier than either tea or coffee, it is only of late years that it has attained any wide popularity, and that chiefly through the energy and enterprise of some of its manufacturers.

The cocoa-plant is the *Theobroma cacao*, the fruit of which resembles a vegetable marrow or cucumber. Embedded in the pulp of the fruit are many seeds, each about the size of a haricot bean, and it is from these that cocoa is prepared. The seeds are separated from the pulp, and placed in heaps for several days to ferment, or 'sweat.' This causes any adherent pulp to become loose, and at the same time modifies the bitterness of the seeds and produces in them a dark colour. They are then roasted, which renders them brittle and loosens the husk, so that the two halves of the seed come out separately on pressure in a machine as **cocoa-nibs.**

The nibs are either sold as such or are ground between hot rollers, which, by melting the fat which they contain, reduces them to a fluid condition. Most of the fat is removed by pressure, and the remainder of the cocoa is then run into moulds, from which it is removed as slabs. For conversion into 'soluble cocoa' or 'cocoa essence' the slabs are again ground down to an impalpable powder.

Various names are applied to different preparations of cocoa. The method of preparing **soluble cocoa** has just been described; but it should be noted that the term is really a misnomer, for, strictly speaking, there is no such thing as a soluble form of cocoa. All that the term implies is that the powder is so finely divided that it easily remains in a state of suspension when mixed with water. In order to aid the suspension, various methods of treating the cocoa are sometimes adopted. The addition of alkali is a favourite device, especially with Dutch manufacturers. It aids suspension by saponifying and emulsifying the fat, and at the same time softens the fibre of the cocoa, so that it can form a sort of pulp with water. It also has the effect of deepening the colour of the beverage, and so of making it look stronger. The free addition of alkali is objected to by some as being injurious to health, but it is very doubtful if that can be fairly alleged against it. There are also methods of increasing the solubility of cocoa by the aid of heat, and to these no objection can be urged.

The term **homœopathic cocoa** is sometimes applied to mixtures of cocoa with other substances, such as arrowroot.

Navy cocoa is one of the purest preparations of the article, being quite free from husk. The ordinary form contains 20 per cent. of Demerara sugar, whilst the 'soluble' form has 20 per cent. of white sugar and 20 per cent. of arrowroot. Both forms are to be regarded as preparations of chocolate rather than mere cocoa.

Chemical Composition of Cocoa.[1]—The general composition of the cocoa-bean is shown in the following table (Bannister):

COMPOSITION OF COCOA.

	Analysis of Raw Trinidad Nibs (Inland Revenue Laboratory).	*Analysis of Shelled Fresh Cocoa-beans (Boussingault).*
Water	5·23	7·6
Fat	50·44	49·9
Starch	4·20	2·4
Albuminous matter, soluble	6·3	10·9
,, ,, insoluble	6·9	
Astringent principle	6·71	0·2
Gum	2·17	2·4
Cellulose	6·40	10·6
Alkaloid	0·84	3·3
Cocoa-red	2·20	
Undetermined	5·80	5·3
Ash	2·75	4·0

[1] For much information on this subject and full bibliography, see United States Department of Agriculture, Division of Chemistry, Bull. 13; also a paper by Cohn, *Zeit. f. Physiolog. Chem.*, xx. 1, 1895. See also Allen's 'Commercial Organic Analysis,' vol. iii., part ii.

The chief ingredient is fat, of which the cocoa-bean contains about half its weight. In the commercial powder, however, there is only about 32 per cent. present, the remainder having been removed by pressure.

Cocoa contains a considerable proportion of nitrogen, but it must be carefully noted that not more than 21 per cent. (Wigner) to 32 per cent. (Stutzer) of this is present as proteids, the rest being in the form of amides. Part also is contained in theobromine. Cohn, indeed, found only 7·9 per cent. of true proteid in raw cocoa-beans, using Stutzer's method.

The chief alkaloid found in cocoa is theobromine. **Theobromine** is known chemically as dimethyl-xanthin, and it is closely related to caffeine, which is methyl-theobromine. Cocoa contains from 1 to 2 per cent. of it, or about as much as there is of caffeine in coffee.

Cocoa contains also some tannin, though probably not of exactly the same form as that found in coffee and tea. Zipperer[1] places the amount at 5·4 per cent. It seems to be combined with a pigment to which the name of cocoa-red is given, but the exact relationship of the two substances has not been fully determined.

Starch is present to the extent of 5·78 to 15·13 per cent. (Ewell).

The proportion of mineral matter is high, amounting in raw cocoa to from 2½ to 3½ per cent. After the fat has been partly removed, the proportion of ash rises to 4 or 5 per cent.; or, if alkali has been artificially added, it may amount to 8 per cent. The ash is strongly alkaline, and in the artificial preparations consists chiefly of potash and phosphoric acid.

The following table contains the results of some analyses which the writer has made of the commonest forms of cocoa in use in this country:

COMPOSITION OF COCOAS.

	Moisture.	Fat.	Nitrogenous Matter (N × 6·25).	Non-Nitrogenous Constituents other than Fat.	Ash.
Cadbury's Cocoa Essence ..	3·9	25·2	20·9	45·2	4·8
Fry's Pearl Cocoa	7·3	15·8	4·3	71·2	1·4
,, Pure ,, ...	5·6	25·6	19·7	43·2	5·9
Van Houten's Pure Cocoa ..	3·0	28·0	20·5	39·7	8·8
Vi-Cocoa	6·3	26·9	17·0	43·8	7·0
Schweitzer's Cocoatina ..	4·3	28·2	19·4	41·8	6·3
Rowntree's Elect Cocoa ..	6·5	25·5	18·0	42·2	7·8
Epps's Prepared Cocoa ..	4·9	15·1	6·7	71·8	1·5
Suchard's Cocoa	4·7	33·2	18·6	36·7	6·8

[1] Quoted by Cohn (*loc. cit.*). See also Fraser, *Journ. of Anat. and Physiolog.*, xviii. 13, 1883, and Wynter Blyth, 'Foods,' 4th edit., p. 455.

Average Composition of a Pure Soluble Cocoa.	
Moisture	4 per cent.
Nitrogenous matter ..	20 „
Fat	26 „
Other non-nitrogenous matter	40 „
Mineral matter	6 „

Probable Percentage of Nutrients in such a Cocoa.	
Proteid	12 per cent.
Fat	26 „
Carbohydrates ..	25 „ (?)

Special attention may be directed to the fact that there is no preparation of pure cocoa which is much poorer in fat than any other.

The following additional analyses are by Ewell[1]:

	Fat.	Fibre.	Cane-sugar.	Ash.	Added Starch.
Fry's Cocoa Extract	30·95	3·89	—	4·24	None
Schweitzer's Cocoatina	31·13	3·70	—	6·33	„
Van Houten's Cocoa	29·81	4·38	—	8·64	„
Blooker's Dutch Cocoa	31·48	3·76	—	6·06	„
Rowntree's Cocoa Extract	27·56	4·42	—	8·48	„
„ Powdered Chocolate	25·84	1·30	51	1·66	Very little arrowroot
Epps's Prepared Cocoa	25·94	1·51	26	3·15	Much arrowroot
Fry's Diamond Sweet Chocolate	18·60	0·81	55	1·16	Much wheat starch and some arrowroot
London Cocoa (unknown maker)	11·13	2·13	32	2·82	Much arrowroot
Chocolat Menier	21·31	1·10	58	1·40	None

Chocolate consists of ground cocoa from which the fat has not been removed, mixed with white sugar, starch and flavourings, such as vanilla, being often added. The inferior varieties are made from unfermented beans, and therefore have a bitter taste. Good chocolate should melt easily in the mouth, and should not sweat out any sugar in the form of a bloom. The taste also should be free from any roughness or astringency. The white part of chocolate creams consists of a mixture of melted cane-sugar and glucose.

The following are some **analyses of chocolate**:

	Water.	*Nitrogenous Matter.*	*Fat.*	*Carbohydrate.*	*Ash.*
Chocolat de Santé[2] ..	10·3	12·5	47·1	26·8	3·3
Van Houten's Chocolate[3]	—	3·9	27·5	66·8	1·8
Plain chocolate[4]	1·89	7·85[5]	21·2	61·9[6]	1·9

Chocolate was first used as a beverage in this country about 1657. It was very popular in the time of Charles II., and fetched 6s. 5d. per pound.

[1] Allen's 'Commercial Organic Analysis,' vol. iii., part ii.
[2] Analysis by Atwater and Woods. [3] Analysis by the author.
[4] Analysis in Leyden's 'Handbuch,' i. p. 109.
[5] 1·67 = theobromine. [6] 7·4 = non-nitrogenous extractives.

INFLUENCE OF TEA, COFFEE, AND COCOA ON DIGESTION.

The influence of these beverages on salivary and gastric digestion is, on the whole, unfavourable; of their effects on intestinal digestion we have little exact knowledge; Roberts considers that they are practically nil. Roberts[1] found that tea markedly inhibits the conversion of starch into sugar by the saliva. If there was even 5 per cent. of tea infusion in the digesting mixture, practically no digestion of starch took place. He attributes this result entirely to the tannic acid in the infusion, but found that tea infused for only two minutes had quite as powerful an effect as when the infusion was prolonged for half an hour. He points out that the addition of a pinch of bicarbonate of soda to the teapot completely suspends the inhibitory effect. Aitchison Robertson[2] confirms these observations as regards tea, but found that coffee had much less influence, and cocoa almost none at all.

The most elaborate investigation of the action of these beverages on digestion in the stomach has been made by Fraser.[3] He found that tea and coffee both retard peptic digestion, but the former to a greater degree than the latter, and that Indian tea has a more powerful effect than China. Further, his observations brought out the interesting result that the digestion of different articles is retarded in unequal measure. Thus, the digestion of white of egg, ham, salt beef, and roast beef, was much less affected than that of lamb, fowl, or bread. Coffee, indeed, seemed actually to aid the digestion of egg and ham. He points out that the foods first mentioned are those most commonly eaten at breakfast, the meal with which tea and coffee are usually taken, and he sees in this an unconscious adaptation to obviate any disturbance of digestion. He attributes the retarding effect to the tannic acid and volatile oil which these beverages contain, the caffeine itself favouring digestion rather than otherwise. The addition of milk, it is important to note, largely removed the retarding influence of tea. Fraser also found that tea increased the production of gas from all except the salted foods. Coffee did not do this, and therefore, he says, should be preferred to tea in cases of flatulent dyspepsia. Tea also reduces the acid-absorbing power of foods; coffee has a similar but less marked effect, while cocoa actually increases it. For this reason cocoa is the most appropriate beverage for patients suffering from the acid forms of dyspepsia.

[1] 'Digestion and Diet,' p. 120.
[illegible] [2] *Physiolog.*, xxxii. 615, 1898. [3] *Ibid.*, xviii. 13, 1883.

Cocoa was found to interfere with artificial digestion, owing to the 'clogging' action of its fine particles preventing the free access of gastric juice to the food. It is very doubtful, however, whether it would have any such effect under natural conditions.

The retarding influence of tea and coffee on peptic digestion has been also established by Roberts,[1] Ogata,[2] and Schultz-Schultzenstein.[3] The former is of opinion that the tannic acid only accounts for about one-half of the inhibitory effects exerted by tea. On the whole, they are agreed that coffee has less influence than tea, provided it be of the same strength, but, inasmuch as the former is usually a stronger infusion than the latter, its effects in actual practice are equally powerful.

Apart from their modifying influence on the chemical processes of digestion, it must be remembered that these beverages sometimes affect the stomach more directly. Thus, the tannic acid and other astringent substances met with in strong infusions of tea may act as irritants to the mucous membrane of the stomach, especially if empty; and the same is true to an even greater extent of the caffeol and other products produced in the roasting of coffee. It is in this way that these beverages may sometimes excite or keep up a condition of chronic gastric catarrh. Cocoa also, owing to the large proportion of fat which it contains, is apt to be irritating to some stomachs, especially as the fat of cocoa appears to be one which is rather difficult of digestion.

As regards the practical inferences to be drawn from these experiments and observations, it may be said that in health the disturbance of digestion produced by the infused beverages is negligible. Roberts, indeed, goes so far as to suggest that the slight slowing of digestion which they produce may be favourable rather than otherwise, as tending to compensate for too rapid digestibility which refinements of manufacture and preparation have made a characteristic of modern foods.

In cases where the digestion is enfeebled, on the other hand, and where the ferments are doing their work with difficulty, the presence of these beverages in the digesting mass may make all the difference between failure and success in the process. In such a case, coffee is probably preferable to tea, and cocoa (provided its fat does not prove a disturbance) is better than either. If tea is taken at all, a good China variety should be selected; it should be infused for as short a time as possible, and should be taken with milk. Second

[1] *Loc. cit.* [2] *Archiv. f. Hygiene*, iii. 204, 1885.
[3] *Zeit. f. Physiolog. Chem.*, xviii. 131, 1894.

cups should be avoided, and it should be drunk after, rather than during, the meal.

Tea and coffee should both be avoided — but especially the former—as an accompaniment to meals which make large demands on the peptic powers of the stomach, such, for example, as meals containing much meat. For this reason 'high' and 'meat' teas are to be condemned. In chronic catarrh of the stomach, coffee is probably more injurious than tea, but in flatulence the former is to be preferred for the reasons already given. As has been previously pointed out, the irritating effects of these beverages on the stomach are more likely to be manifested when the latter is empty. For this reason, the morning cup of tea—'tea veniente die,' as it has been called—may sometimes prove harmful. On the whole, the effects are probably least when the stomach is neither quite empty nor too full, but contains a moderate amount of easily-digested food—a state of things which, one is glad to say, is pretty well true at 'afternoon tea.'

As concerns the **length of stay of these beverages in the stomach**, the following observations have been made:

200 c.c. (1⅓ teacups) of tea remain	..	1½ hours
" " " coffee remain	..	1¾ "
" " " cocoa made with water remain	..	1¾ "
" " " " " milk	..	2½ "

In other words, the larger the amount of solid matter which the beverage contains, and the more it approximates to the characters of a true food, the longer does it tend to remain in the stomach.

There are no available observations on the **absorption** of tea and coffee. If 110 to 120 grammes of cocoa are taken daily, the loss of nitrogenous matter is about 46 per cent., but of the fat only 4·6 per cent. escapes digestion. The carbohydrates are entirely absorbed.[1] If more than 50 grammes (ten teaspoonfuls) were taken at a time, digestion was always upset.

Uses of Tea, Coffee and Cocoa.

The action of tea and coffee on the body depends entirely upon the tannic acid, caffeine and volatile oil which these beverages contain. The effects of the tannic acid are purely local, and have already been pointed out, when speaking of the influence of tea and coffee on digestion. The caffeine and volatile oil, on the other hand, have

[1] Cohn, *loc. cit.* Weigimann found that the fat was absorbed to 94·5 per cent., and the nitrogenous matter to 42 per cent., when 195 grammes of cocoa-powder boiled in water were taken in two days.

a general pronounced physiological action, to which attention must now be directed.

Caffeine, like alcohol, is a **stimulant**, but, unlike that substance, it exerts its effects upon the central nervous system even more than upon the heart. Physiological experiments have shown that after the administration of caffeine the time occupied by nervous processes is shortened, and reflex excitability is increased. At the same time, it removes the sense of fatigue, and is apt to produce sleeplessness. It is interesting to note that these stimulating effects upon the brain were amongst the earliest to be recognised of the physiological actions of tea and coffee. Tradition has it that in the remote ages there was a holy Asiatic, Prince Darma, who spent his nights in meditation on the Infinite. One night his ecstasy was disturbed by sleep. On waking, he was so enraged at his weakness that he cut off his eyelids and flung them on the ground. On visiting the spot some time later, he found that where each eyelid fell a small shrub had grown up. He infused the leaves of the shrub, and ever afterwards, by simply drinking some of the infusion, he was able to keep sleep at bay. That shrub was the tea plant!

A similar tradition as regards the stimulating effects of coffee is thus recorded by Johnston:[1]

'In antique days a poor dervish, who lived in a valley of Arabia Felix, observed a strange hilarity in his goats on their return home every evening. To find out the cause of this, he watched them during the day, and observed that they eagerly devoured the blossoms and fruit of a tree which hitherto he had disregarded. He tried the effect of this food upon himself, and was thrown into such a state of exaltation that his neighbours accused him of having drunk of the forbidden wine. But he revealed to them his discovery, and they at once agreed that Allah had sent the coffee-plant to the faithful as a substitute for the vine.'

As a result of this action on the nervous system, tea and coffee are great aids to mental work, and the former, as De Quincey remarked, will always be the beverage of the intellectual. As a learned Chinaman said of it more than 2,000 years ago:

> 'It tempers the spirits and harmonizes the mind,
> Dispels lassitude and relieves fatigue;
> Awakens thought and prevents drowsiness,
> Lightens or refreshens the body, and clears the perceptive faculties.'

The vital centres share in the stimulation produced by caffeine, as well as the brain cortex. After its administration, the respiratory

[1] 'Physiology of Common Life,' p. 148

movements are deeper and more frequent, and the heart beats more forcibly and rapidly. It is thus an important aid in combating impending paralysis of these centres in cases of coma. Binz, for example, found that dogs which had been rendered comatose by alcohol could be aroused after the administration of coffee. The fact that coffee is an antidote to alcohol is another justification for its use after dinner.

Caffeine, as we have seen, stimulates the heart through the cardiac centre, but it probably has a direct action as well. When administered in the form of tea and coffee, its action is aided by the fact that these beverages are usually taken hot. The increased force and frequency of the heart's action induces a more profuse flow of urine,[1] and so aids in the removal of waste products from the body. This, along with the stimulation of the nervous system and heart, makes tea and coffee of use in some low forms of fever, conditions in which their administration might with advantage be more extensively adopted.

The question has been much debated whether or not caffeine lessens the waste of the body. Some, for instance, have contended that it acts as a kind of drag upon the chemical changes in the tissues, rendering them slower, and so enabling the body to get on with less food than would otherwise be necessary. For this contention, however, there is no satisfactory evidence. Indeed, all experiments go to prove the contrary, namely, that caffeine **tends to increase rather than diminish tissue waste.**[2] It does not prolong life in starvation, although it may perhaps lessen the *feeling* of hunger. Experiments with the ergograph, too, have shown that tea and coffee are in no sense muscle foods, although they can temporarily increase muscular power by abolishing nervous fatigue, so long, at least, as the muscles are not completely exhausted.[3]

The action of the **volatile oil** contained in tea and coffee has not been very fully investigated, and would appear to be slightly different in the case of the two beverages. It, too, appears to act as a cerebral and cardiac stimulant, and to it, perhaps, some of the unpleasant symptoms, such as headache and giddiness, which afflict those who, like tea-tasters, indulge in large quantities of these beverages are to be attributed.

These oils seem also to have an action upon the bloodvessels which is different in the case of tea and coffee respectively, for the

[1] Caffeine appears to have a direct stimulating action on the renal cells as well.
[2] See Richet's 'Dictionary of Physiology,' article 'Caffeine.'
[3] Schumburg, *Archiv. f. Anat. in Physiolog.*, 1899, Sup. Bd., p. 289.

former tends rather to dilate the superficial vessels and render the skin moist, while coffee has an opposite action. It is in this way that tea is said to warm the body when cold, by making the circulation more brisk, and to cool it when heated, by increasing evaporation from the surface.

We may conclude, then, that **tea and coffee are in no sense foods,** in that they can neither build up the tissues nor provide them with potential energy, though they may perhaps act the parts of lubricants in the machinery of the body by diminishing nervous fatigue. It is no doubt this subjective feeling which has led to the very extended use of these beverages by men in all ages and in all countries.

When we turn to the question as to what extent these beverages can be indulged in without injury to health, one finds it very difficult to give a definite reply. The part played by personal peculiarity and habit in the matter is very great. It has been pointed out, for example, that the usual result of drinking tea and coffee is to produce wakefulness, but yet there are persons who find their use in the evening conducive to sleep. Some people, again, can drink tea quite freely, but are made ill by coffee or *vice versâ*. Facts like these must be recognised although one is unable to explain them, and they make it impossible to lay down definite rules regarding the dietetic use of tea and coffee.

The bad effects usually attributed to an excessive indulgence in these beverages are of two kinds, affecting either the nervous system or the digestion. The increased excitability of the nervous system which they produce may lead to general 'nervousness' (the patient starts, for instance, on the slightest sudden noise, or, as a tea-taster once put it to the writer, he becomes 'jumpy'), tremulousness, palpitation, loss of sleep, giddiness, and depression.

The disturbance of digestion which tea or coffee, but especially the former, produces is partly due to a direct interference with the chemical part of the process, as already described, but in part also is brought about indirectly through the nervous system. The dyspepsia which results is of the atonic type, digestion being slow, often accompanied by flatulence and attended by a feeling of sinking or depression and disturbance of the heart's action.

Whilst one may fully admit the importance of the part played by tea and coffee in the production of such symptoms, yet the extent to which they prevail has probably been greatly overestimated. It certainly seems an exaggeration to talk, as some people do, of the existence of 'tea drunkenness.' All that one is entitled to infer is

that these beverages should be used sparingly by 'nervous' people and by those whose digestion tends to be feeble and slow.

The place of **cocoa** in the diet is not really very different from that of tea and coffee. An examination of the chemical composition of cocoa might lead one to suppose that it was of considerable nutritive value. But that would be a mistake. Theoretically, cocoa is a valuable food, but practically it is not, the reason being that so little of it can be taken at a time. In this respect it is exactly comparable to many of the beef-extracts already considered.

It takes about 10 grammes of cocoa to make a breakfast-cupful of the beverage, and, assuming the average composition given already, this would yield about 40 Calories of energy. It would, therefore, require fully seventy-five such cupfuls to yield the total amount of potential energy demanded of the body daily—obviously an impossible quantity. Of course, if the beverage is prepared entirely with milk and plenty of sugar it becomes an important food, but that is due to the milk and sugar, and not to the cocoa. Chocolate is of more value. Half a pint of milk and 2 ounces of chocolate yield together fully 400 Calories, and 3½ pints would suffice to supply all the energy and a large part of the building material required in a day.

The action of cocoa on the nervous system is very much less than that of tea or coffee, owing to the small amount of alkaloid which it contains; indeed, it may be practically ignored. The special preparation known as Vi-Cocoa, on the other hand, has an influence on the brain from the addition to it of a certain proportion of **kola.** The latter contains a considerable proportion of caffeine as well as a glucoside (kola-red), and it is to these ingredients that its action on the nervous system is to be attributed.[1] Kola is said to possess remarkable sustaining qualities, prolonging muscular contraction and abolishing fatigue; but its action seems to be uncertain, and the addition of such a drug to a beverage intended to be used regularly is a practice which can hardly be commended.

[1] See *Brit. Med. Journ.*, June 4, 1898; *Food and Sanitation*, February 9, 1895; David Émile, Thèse, Paris, 1894; Labesse, Thèse, Paris, 1897.

CHAPTER XIX

ALCOHOL

THE only form of alcohol with which we are seriously concerned in dietetics is ethyl alcohol (C_2H_5OH). It is produced, in all the beverages in which it is found, from the fermentation of sugar by yeast, according to the well-known equation:

$$\underset{\text{(sugar)}}{C_6H_{12}O_6} = \underset{\text{(carbonic acid)}}{2CO_2} + \underset{\text{(alcohol).}}{2C_2H_5OH.}$$

We shall subsequently discover that the special characters of different alcoholic beverages depend to some extent on the particular kind of sugar and yeast concerned in the fermentation. It must also be borne in mind that the process of fermentation as carried on in the manufacture of alcoholic drinks is never such a simple affair as the above equation might induce one to believe. Bye-products are invariably produced as well as alcohol, and the nature and amount of these profoundly influence the character of the resulting beverage. Of all alcoholic drinks, however, it remains true that the principal constituent by which they affect the nutrition of the body is ethyl alcohol. It consequently becomes of the first importance for us to study minutely the effects of alcohol on the body, for upon the results of such study our opinion as to the value or otherwise of alcoholic drinks, both in health and disease, must ultimately rest. I propose, therefore, to devote this chapter to a description of the physiological effects of alcohol.

LOCAL EFFECTS OF ALCOHOL.

The local effects of alcohol are those of a chemical irritant. If some strong spirit, such as whisky or brandy, is taken into the mouth, a sensation of burning is produced, owing to the irritation of the nerve endings, and by-and-bye the mucous membrane becomes

somewhat corrugated and whitened by reason of the removal of water from its surface cells and the coagulation of their protoplasm. Repeated local irritation of this sort is the exciting cause of the pharyngitis and gastric catarrh often observed in those who are in the habit of drinking neat spirits, especially on an empty stomach, where the alcohol can come into direct contact with the mucous membrane. The stimulation of the nerves of the mouth brings about reflexly a profuse flow of saliva, and in this way alcohol may promote salivary digestion, for its retarding influence in the chemical transformation of starch into sugar is so slight that it may be neglected.[1]

EFFECTS OF ALCOHOL ON DIGESTION.

Arrived in the stomach, alcohol mixes with the gastric contents, and affects the processes of digestion in several very important directions. The first point to notice is that alcohol has, by itself, surprisingly little influence on the *chemical* processes of digestion. When it is present to the extent of only 1·2 per cent. of the digesting mixture, its influence is rather favourable than otherwise. If the proportion of alcohol is increased to 5 or 10 per cent. the chemical changes of digestion become retarded, but it is only when 20 per cent. of alcohol is present that the process is arrested altogether.[2]

This immunity of pepsin to the action of alcohol is very striking, and as a consequence of it one cannot regard pepsin wines as irrational products of pharmacy. It is interesting to note that pancreatic digestion is much more sensitive to alcohol, for if the latter is present to the extent of merely 2 or 3 per cent., the process is distinctly retarded. But digestion is not merely a chemical process. The movements of the stomach walls play a large part in it also. And here the action of alcohol, in dietetic doses at least, is entirely favourable, for it has a wonderful power of increasing the activity of stomach peristalsis. Binz, for example, found that the administration of eight small teaspoonfuls of brandy at short intervals, for the space of an hour, increased very considerably the rate at which olive oil was discharged from the stomach. He repeated the experiment with similar results in six cases.

Alcohol not merely increases the vigour of the stomach move-

[1] The presence of even 45 per cent. of alcohol does not altogether stop amylolytic action (Roberts). This is confirmed by Aitchison Robertson and by Chittenden and Mendel.

[2] See Buchner, *Deut. Archiv. f. Klin. Med.*, xxix. 537, 1881. See also Chittenden and Mendel, *op. cit. infra.*

ments: it promotes very powerfully the secretion of gastric juice.[1] This it does not merely by directly irritating the nerves of the mucous membrane, but also indirectly by its presence in the blood after absorption. This indirect action of alcohol is of great importance, for it means that even when all the alcohol swallowed has left the stomach, and when any slight retarding influence which it may have exerted on the merely chemical processes of digestion has ceased, it is still able to affect the disintegration of the food by bringing about a more profuse and sustained flow of the digestive juices.[2]

When one weighs the very slight retarding influence of alcohol on the *chemical* part of digestion against its power of promoting the stomach movements and the flow of gastric juice, one finds that the balance is favourable to digestion, and alcohol must therefore be regarded as a digestive stimulant. In accordance with this, direct experiment on the human subject has shown that alcohol in dietetic quantities, *e.g.*, 30 to 40 grammes of brandy (about two tablespoonfuls), taken before or during meals, actually shortens the time required for the digestion of a meal by about half an hour.[3] Red wines were found to have a similar effect.

The net influence, then, of moderate doses of alcohol upon stomach digestion, even in health, is favourable rather than the reverse, while in some conditions of disease its power of exciting the movements of the walls of the stomach and of promoting the flow of gastric juice render it a valuable aid to the digestion of solid food. On the other hand, it is to be noted that in intoxicating doses alcohol interferes with digestion, owing to the general nervous and vascular depression which it brings about.

The importance of these conclusions regarding the influence of alcohol on digestion can hardly be overrated, for they explain much of the benefit which is so often derived from the moderate use of alcohol, even in health, and still more in cases of disease.

Unlike water, alcohol is freely absorbed by the mucous membrane of the stomach. Chittenden and Mendel found that when the pylorus was ligatured 200 c.c. of a 37 per cent. solution of alcohol disappeared from the stomach of a dog in about three hours, and

[1] For some very valuable experiments on this subject see Chittenden and Mendel, *American Journal of the Medical Sciences*, January-April, 1896, and *American Journal of Physiology*, vol. i., No. 2, p. 164, 1898. Full references are given in these papers to the results of other workers.

[2] The gastric juice is not merely increased in quantity. The proportion of its solids and its acidity are raised as well (Chittenden and Mendel).

[3] Penzoldt and Wolffhardt, *Münch. Med. Woch.*, p. 608, 1890.

they add that one may well believe that when 6 or 8 grammes of alcohol are swallowed in the form of wine or beer, 80 to 90 per cent. of it will have entered the blood within half an hour. This is of great importance, for it means that *alcohol requires no digestion*, but is able to pass at once into the blood. Hence much of its value as a rapid restorative, even when all digestive power is in abeyance. Alcohol is not only rapidly absorbed from the stomach itself, but powerfully promotes the absorption of other substances. If, for example, a dose of chloral dissolved in water be injected into a stomach the pylorus of which is occluded, narcosis does not follow, but if even very little alcohol is present the usual soporific results soon set in. It is probably for this reason that sleeping-draughts are often much more rapid in their effects when given along with a glass of whisky or brandy, and the rapid action of medicines in the form of tinctures may be explained in the same way.

The passage of alcohol out of the stomach into the blood is counterbalanced by a flow of water from the blood into the stomach. The 'endosmotic equivalent,' as it is called, of absolute alcohol for animal membranes is 4·13, and this means that for every gramme of alcohol which passes in one direction 4·13 grammes of water pass in the other. If, then, alcohol be administered to a patient with a dilated stomach, the result may be that the total amount of fluid in the organ is ultimately increased.

On the absorption of foods in the intestine alcohol in moderate quantity does not seem to exercise any effect ';[1] in other words, one may digest his food better for taking a certain amount of alcohol at meals, but he will not get any more nourishment out of it.

Alcohol as a Stimulant.

The Latin word *stimulus* means a whip or spur, and a stimulant is anything which is capable of spurring on an organ to the performance of more work. As a general rule, it may be said that stimulants act either upon the nervous system or upon the heart, and alcohol is one which affects the latter much more than the former. It is doubtful, indeed, whether alcohol can properly be regarded as a nervous stimulant at all. Any symptoms of increased brain activity which it induces are probably to be regarded as the consequence of an increased flow of blood through the brain rather than as the result of any direct action upon the cerebral cells.

The stimulating action of alcohol upon the heart, on the other

[1] Zuntz and Magnus Levy, *Pflüger's Archiv.*, xlix. 438, 1891, and *ibid.*, liii. 544, 1893.

hand, is one of the greatest importance, and results, in health, not only in a greater frequency of contraction, but also in an increased force of each beat. In disease, however, when the heart is beating rapidly, but feebly and ineffectually, the effect of alcohol is often to diminish the number of the beats while improving their force, and as long as these effects are being produced in a case of acute illness, one is tolerably safe in assuming that alcohol is doing good.

The stimulating effect of alcohol on the heart would appear to be exerted even before absorption has had time to take place, probably through the medium of the nerves of the stomach, which are, as is well known, in very close relation to those which control the action of the heart. Sometimes, indeed, this reflex action is so powerful that it actually leads to a stoppage of the heart altogether. This would seem to be the explanation of those cases of sudden death which occasionally ensue upon the swallowing of large quantities of strong spirits on an empty stomach, as, for example, when a man drinks a pint of whisky for a wager.

After its absorption into the blood, alcohol is able to affect the heart more directly, while at the same time it brings about a dilatation of the bloodvessels on the surface of the body, and so diminishes the resistance to the onward flow of the blood. That this diminution of resistance is not, however, the sole cause of the increased rapidity of the heart's action is shown by the fact that alcohol can raise the pulse-rate even although the bloodvessels have been already allowed to dilate by previous division of the spinal cord. The action on the heart, then, is a direct one.

Of many observations illustrating these **effects of alcohol on the circulation** I would only cite one by Parkes and Wollowicz, who found in the case of a man that the administration of from 1 to 7½ ounces of rectified spirit daily raised the pulse-rate by ten beats per minute as compared with the period when no alcohol was being taken. They found, moreover, as other observers have found before and since, that this overactivity of the heart was followed by a period of depression in which the beat was both slower and feebler than normal. It is important to bear in mind this after-action of alcohol. It means that the temporary benefits obtained from its stimulating action have to be paid for by subsequent cardiac depression, for alcohol is not, apparently, a food for the heart, but merely a means of enabling that organ to draw for the time being on its reserve of strength. It should be a warning, too, not to begin the administration of alcohol too early in a case of acute disease,

lest one arrives at the period when no further stimulation is possible before the crisis is past.

It has been said that alcohol tends to dilate the peripheral bloodvessels. This, indeed, is amongst its leading physiological actions, and one the significance of which it would be difficult to overrate, for it explains many of the apparently contradictory effects of alcohol on the body. There is reason to believe, for instance, that alcohol tends to anæsthetize rather than stimulate the brain, but by dilating the cerebral bloodvessels it may so flush the brain with blood that intellectual activity may be temporarily increased before the anæsthetic effects have had time to manifest themselves. Thackeray is said to have remarked that he got some of his best thoughts 'when driving home from dining out with his skin full of wine.' We need not doubt it, for the statement embodies a physiological truth. It *was* his skin which was full of wine, for alcohol dilates the surface bloodvessels, and along with them those of the brain also, but by the time he got home one may expect that the anæsthetic effects of the alcohol would have begun to exert themselves and the thoughts would have fled. By flushing the brain with blood, alcohol may produce temporary excitement and aid the imagination, but it ends by dulling the edge of the intellect, and is unfavourable to sustained mental work.

Another apparent inconsistency in the action of alcohol which is explained by its effects on the bloodvessels is its **influence on the temperature** of the body. Alcohol, as we shall see immediately, is a fuel, and by its oxidation in the tissues produces heat, just as it does in a spirit-lamp; but by dilating the surface bloodvessels it causes more heat to be given off by radiation than its own combustion produces, so that the net result is that the temperature of the body is lowered. It is all the more essential to grasp this fact, for the reason that the very flushing of the skin with blood produces a deceptive feeling of warmth, and for that reason alcohol is often taken 'to keep out the cold.' That is a great mistake. Alcohol does not 'keep out the cold,' but lets out the heat of the body, and consequently the consumption of spirits is a very bad means of fortifying one's self to meet a low external temperature, as was found out by the Arctic explorers long ago. By unlocking the surface bloodvessels and allowing of the escape of heat, alcohol often renders great service in the treatment of fevers; but in health the paralysis of the heat-regulating mechanism which it induces may be dangerous, or even fatal, and one finds as a matter of fact that persons who are frozen to death, in this country at least, have

usually met with that fate through their having been in a state of intoxication when the cold overtook them.

On the other hand, if one has been already exposed to cold, and the blood has been driven into the internal viscera and is stagnating there and about to produce congestion, the timely administration of alcohol may save the situation by once more bringing about a proper distribution of the blood.[1] By all means, then, take alcohol on coming indoors when wet or chilled, but carefully avoid it when about to proceed out to meet the frost or rain.

There can be no doubt that prolonged over-indulgence in alcohol may cause the vascular paralysis of which we have spoken to become permanent, whence the bloated look and purple nose of the drunkard. In such a case the beneficial effects which should otherwise be obtained from the administration of alcohol in acute disease are no longer manifested. The heart and bloodvessels have been so often stimulated that they have ceased to respond to the spur, and the patient often pays the penalty with his life.

Influence of Alcohol on Metabolism.

Alcohol is a protoplasm poison or anæsthetic, but is itself easily burnt up in the body. That is the key to the proper understanding of its action on metabolism. Let us see more exactly what the statement means. We have already seen (p. 22) that the cells of the body may be regarded as being bathed in fluid which contains in solution particles of proteid, of carbohydrate, and of fat, and we have further learnt that there is reason to believe that these are broken down by the cells with different degrees of facility, proteid being most easily destroyed, then carbohydrate, and lastly fat. If now alcohol gets access to the cell and partially paralyzes or anæsthetizes it, the cell will lose its power of breaking down those compounds, such as fat, with which it has, even in a condition of full activity, most difficulty in coping. Alcohol, then, saves fat from combustion; in other words, it is a fat-sparer. It also appears, though with greater difficulty, to be able to spare carbohydrate, but it is exceedingly doubtful whether it is ever able so far to paralyze the cell as to destroy its power of dealing with proteid. This action of alcohol on cellular activity is quite in keeping with what we know of the effects of other cell poisons. Arsenic, for instance, seems to impair the fat-destroying power of the cells, while there is some reason to suppose that lead interferes with their ability to break down proteid, and so

[1] See also Brunton, 'The Physiological Action of Alcohol,' *Practitioner*, xvi., 1876.

may predispose to gout, while hydrocyanic acid is the most powerful protoplasm poison known, and by paralyzing the activity of the cells in every direction at once leads to death.

Alcohol, then, certainly spares fat and sometimes carbohydrate, but in so doing it is itself consumed, and yields heat and energy to the body. Of this fact, once much disputed, there is no longer any doubt, and it at once entitles alcohol to rank as a *food*. Careful experiments have shown that the complete combustion of 1 gramme of alcohol in the body yields 7 Calories of energy; in other words, 131 grammes of alcohol will yield as much heat as 100 grammes of fat, which means that 1 ounce of alcohol supplies as much fuel as 1 ounce of butter[1] (about 200 Calories).

This statement must not be misunderstood. It does not follow from it that alcohol is as good a source of heat in the food as fat. Quite the contrary is the case, for, as we have already seen, by dilating the surface bloodvessels, alcohol may cause more heat to be lost than it is itself capable of producing. Further, alcohol is rapidly burnt up, and the heat which it yields is quickly dissipated, while fat produces heat in a slower and more equable fashion. In large doses the general paralysis of cellular activity which alcohol produces is so great that heat production is diminished at the same time as heat loss is increased, and the final result is a great lowering of the body temperature, which may even amount to 15° F.

There is still less reason to regard alcohol as a useful muscle food. Even granting that it can be oxidized in the muscles in such a way as to be capable of yielding energy, any value which it may possess in virtue of that is seriously counterbalanced by the paralyzing effect which it exerts on nerve cells, dulling the sense of exhaustion which is Nature's warning, so that, as experience has shown, the consumption of alcohol during muscular work tends to hasten rather than delay the onset of fatigue.[2]

Seeing that alcohol in sparing fat and carbohydrate is itself oxidized, one is not surprised to learn that its administration does not increase or diminish either the intake of oxygen or the output of carbonic acid gas.[3] On the other hand, if the amount of fat or carbohydrate in the diet is already insufficient for the needs of the body, alcohol is able to supplement them by acting as a source of heat. Atwater found that from one-fifth to one-seventh of the total Calories

[1] 80 per cent. of fat.

[2] See ergographic experiments, by Destree, *Quarterly Journal of Inebriety*, January, 1899.

[3] Zuntz, *Fortschr. d. Med.*, v. 1, 1887, and Geppert, *Arch. f. Exper. Path. u. Pharmak.*, xxii. 367, 1887.

of the diet could be thus replaced by alcohol, and this explains the observation of Hammond, that when he added alcohol to a diet on which he was losing weight the loss was immediately stopped.[1]

Anstie[2] has recorded some striking instances of a similar sort in which alcohol seemed to act as a true food. He kept patients alive during acute illness for many days on nothing but large quantities of brandy, and found that they had not emaciated during that time nearly so much as they would have done if they had been merely living on their own tissues. Nor is this surprising, for the amount of alcohol (12 ounces of brandy) supplied daily was capable of yielding close upon 1,000 Calories to the body.

It has been said that it is very doubtful whether alcohol ever affects the power of the cells to destroy proteid; in other words, alcohol is **probably not a proteid-sparer.** One can only speak tentatively in this matter, for many experiments might be quoted both for and against a proteid-sparing action of alcohol. On the whole, however, the weight of the latest and most exact experiments is opposed to the belief that alcohol in any way diminishes nitrogenous waste, and, indeed, it sometimes seems actually to increase it.[3] The point is of some importance, for it has been believed by many that the administration of alcohol has the power of checking the rapid waste of nitrogenous tissue which goes on in fever. Unless, however, the behaviour of alcohol is very different in fever from its action under healthy conditions, a proposition for which there is no real evidence, one is not justified in assuming that it has any appreciable influence in that direction.

As regards the general influence, then, of alcohol on metabolism, we may safely conclude (1) that it is burnt up in the body, sparing fat and carbohydrate in the process, but that (2) the weight of evidence is against the view that it has any important power of diminishing nitrogenous waste.

The question next arises, At what rate does the combustion of alcohol in the body go on? Is it so rapid that all of it is decomposed, or is there time for some of it to be eliminated unchanged? The reply to these questions is that much depends on the quantity of alcohol taken. In non-intoxicating doses, exceedingly little, not

[1] 'Physiological Memoirs,' p. 47, 1863.

[2] 'Stimulants and Narcotics,' London, 1864.

[3] For a useful summary of previous work and some fresh experiments on this subject, see Rosemann, *Zeit. f. Diät und Physik. Therapie*, i. 138, 1898, and *Pflüger's Archiv.*, Bd. 77, p. 405. See also Poul Bjerre, *Skandinav. Archiv. f. Physiol.*, Bd. 9, 323, 1899; Von Noorden, *Jahres-Ber. f. Thierchemie*, xxi. 354, 1891; Atwater, United States Department of Agriculture, Bulletins 63 and 69; and Chittenden, *Journal of Physiology*, xii. 220, 1891.

more than from 1 to 3 per cent. at most, passes off from the body unchanged.[1] If, on the other hand, the quantity consumed is sufficient to produce intoxication, the amount of alcohol which escapes combustion may rise to more than 10 per cent. of the whole dose.

Whenever the proportion of alcohol circulating in the blood becomes greater than the cells can rapidly decompose, its effects as a protoplasm poison become manifest. In their extreme form those effects culminate in intoxication, which is really a condition of cell paralysis, so that the expression 'paralytic drunk' has a truer physiological meaning than those who use it commonly suppose. The brain cells seem to be peculiarly sensitive to the paralyzing action of alcohol, so that the brain is the first to show the effects of an overdose. It is paralyzed from above downwards, the higher centres being affected first. Now, the highest centres are the controlling centres of the brain, and hence loss of control, intellectual, emotional and muscular, is the earliest fact of alcoholic intoxication. It is only in the extreme degrees of the condition that the 'driving centres' of the brain, the centres of organic life which maintain the action of the heart and provide for respiration, become involved in the paralysis, and the condition then is one not merely of intoxication, but of coma, and threatens life itself.

The bad effects of alcohol taken in quantities sufficient to produce intoxication are too apparent to require to be insisted upon. It must be remembered, however, that the habitual consumption of alcohol in quantities which, though insufficient to produce any of the outward and visible signs of intoxication, are yet beyond the immediate oxidizing power of the cells, may end by playing havoc with the tissues. Here, again, the brain seems specially liable to suffer, probably owing to its being one of the most highly organized and delicate tissues in the body. As the result of chronic alcoholism it becomes the seat of various degenerative changes to which the motor centres seem less resistant than the sensory. I think, too, that one can recognise in the habitual alcoholic a certain degree of paralysis of the moral perceptions, and in special a loss of the sense of truth. Throughout the body generally the presence of even a slight amount of undecomposed alcohol leads to a diminution of the chemical energy of the cells, which interferes with the ordinary course of metabolism, and may result in chronic disease. The metabolism of fat is, for reasons already pointed out, most apt to be interrupted,

[1] See Anstie, 'Final Experiments on the Elimination of Alcohol from the Body,' *Practitioner*, xiii. 15, 1874. See also Binz's 'Lectures on Pharmacology.'

and hence alcoholism is a common cause of fatty degenerations and an important factor in many cases of obesity. By delaying the decomposition of carbohydrates, it aids in the production of some forms of diabetes, and there can be no doubt that it plays a large part in that alteration of proteid metabolism which seems to be the basis of gout.[1]

It seems reasonable, also, to suppose that the excretion by the kidney and other organs of undecomposed alcohol may act as an irritant and bring about changes in structure, which may end in serious interference with the discharge by the affected organ of its normal functions. It is in this way, for example, that the habitual consumption of more alcohol than can be decomposed in the body may produce chronic nephritis. All these considerations bring home to one the very great importance of ascertaining, if only approximately, how much alcohol can be so completely oxidized in the body that there will be none left over to exercise upon the tissues those injurious influences of which we have just been speaking. Experiments carried out with a view of determining this point have shown that 1 to 1½ fluid ounces of absolute alcohol is about the amount which can be completely oxidized in the body in one day, and in such a way that none of its paralyzing or narcotic effects are manifested, and no unchanged alcohol appears in the urine (Parkes). This quantity of alcohol would be contained in the following amounts of some of the commoner alcoholic drinks:

Brandy or whisky (50 per cent. alcohol)	2 fluid ounces,	or 1 glass.
Port, sherry, and other strong wines (20 per cent. alcohol)	5 ,, ,,	or 2½ glasses.
Claret, hock, champagne, and other weaker wines (10 per cent. alcohol) ..	10 ,, ,,	= 1 tumblerful.
Bottled beer (5 per cent. alcohol) ..	20 ,, ,,	= 1 imperial pint.

Whilst we may admit the probable accuracy of the data on which these calculations are founded, two modifying factors have to be considered. The first of these is the question of idiosyncrasy. There can be no doubt that **personal peculiarity** plays a very large part in determining the amount of alcohol which can be consumed by any given individual without injury to health. Some persons seem to be able to burn up alcohol more rapidly and completely than others, for reasons which do not seem to be connected with any determinable peculiarity of physical organization. Certainly every one must have known persons who were able to go on consuming daily a far larger quantity of alcohol than the standard above laid down, and yet with-

[1] See also Von Strümpell, 'Ueber die Alkohol Frage vom Aerztlichen Standpunkt' aus 65ten Versamml. deut. Naturforscher zu Nürnberg, p. 97, 1893.

out their health being appreciably impaired by the indulgence. Indeed, when one recalls the drinking exploits of our grandfathers and the prowess of the 'three-bottle men,' one is almost tempted to think that the power of our tissues to oxidize alcohol has actually undergone a decline. Apart from mere peculiarities of constitution, it must be obvious that the surroundings and habits of each individual must affect very greatly the amount of alcohol in which he can indulge with safety. The rapid oxidation which is the result of an active, open-air life, for example, enables an amount of alcohol to be consumed with impunity which would work disastrous consequences in one of sedentary pursuits.

The other factor which must influence any calculation as to the amount of alcohol which can safely be consumed daily is the form and mode in which the alcohol is taken. It will be generally conceded that the same quantity of alcohol is less likely to be injurious if taken in a dilute than in a concentrated form. It must be evident also that an amount of alcohol which would be harmful if swallowed at one time may be free from risk if spread evenly over the day. The danger to be avoided is flooding the circulation at one time with an amount which it is beyond the power of the cells to oxidize.

Use of Alcohol in Health.

We have seen that one cannot deny to alcohol the right to be regarded as a 'food' in the scientific sense of the term. We have also seen, however, that it cannot be regarded as a food of any great practical importance, for it is merely able to replace a certain amount of fat, and perhaps also of carbohydrate, in the body, while its secondary effects on the nervous and vascular systems counteract, to a large extent, the benefits derived from the production of heat and energy by its oxidation. As a food, also, alcohol is open to the additional objection of being very costly. Even in Bavaria, the land of cheap beer, it has been calculated that alcohol, in that, its least expensive form, is eight times dearer than bread, from the point of view of the amount of heat yielded.

It has been shown that alcohol is not favourable to the production of sustained muscular effort, and that it may even do harm by paralyzing the sense of fatigue which is the natural check on excessive exertion. Nor can it be said that it is favourable to the production of perfectly healthy brain-work. An interesting book[1] was published a few years ago in which were gathered together the

[1] 'Study and Stimulants,' A. A. Reade (Simpkin, Marshall and Co., 1883).

results of the personal experience of leading men in literature, science and art on the effects of stimulants as aids to intellectual work. It is interesting to note that, out of the 124 individuals consulted, none ventured seriously to recommend alcohol as an aid in the performance of mental labour.

We may conclude, then, that alcohol is an unnecessary article of diet in complete health, although, if used within the limits already indicated, it cannot be said to be harmful, and may even, indeed, be beneficial; for, as Matthew Arnold has said in the book already referred to, 'wine used in moderation seems to add to the *agreeableness* of life—for adults, at any rate—and whatever adds to the agreeableness of life adds to its resources and power.'

It is in conditions just short of health, however—in old age, overwork and fatigue—that the beneficial effects of alcohol become most marked. They may be traced almost entirely to its favourable influence on digestion, and hence a good rule for the use of alcohol in all conditions short of actual disease is to take it only at meals, and in such quantities as are found to improve the appetite for food and the capacity for digesting it. As regards the form in which it should be used, beer seems most natural for youth, wine in middle life, while spirits may be reserved for the aged.[1]

Use of Alcohol in Disease.

Just as the effect of alcohol on the digestion is the test of its value in health, so its effects on the circulation are the criterion of its usefulness in most cases of acute disease. As long as the efficiency of the heart is improved by its administration, alcohol is doing good. In fever, its power of lowering temperature is also of use, while it

[1] In the *Contemporary Review* for 1878 and 1879 there will be found a very interesting discussion of the alcohol question, in which several distinguished physicians and surgeons took part. The opinion of most of them was that the moderate use of alcohol in health is harmless, if not indeed actually beneficial. In Dr. Wilks' paper the view that alcohol is essentially a *narcotic* rather than a stimulant is strongly presented, while Dr. Moxon deals in the most interesting manner with its effects on the mental faculties. The conclusions of Dr. Murchison—which are not, however, in complete harmony with those of most of the other contributors—are as follows:

1. A man in good health does not require alcohol, and is probably better without it. Its occasional use will do him no harm; its habitual use, even in moderation, may, and often does, induce disease gradually.

2. There are a large number of persons in modern society to whom alcohol, even in moderate quantity, is a positive poison.

3. In all conditions of the system characterized by weakness of the circulation, the daily use of a small quantity of alcohol is likely to be beneficial, at all events for a time.

On the whole, the views presented by these writers may be regarded as fairly representing contemporary medical opinion on the subject.

may, perhaps, check somewhat the tissue waste which is so marked a feature of acute fevers, although we have seen reason to doubt this—at least, as far as the nitrogenous tissues are concerned. To this point, however, we shall return in another chapter (p. 464). There are grounds also for the belief that alcohol actually increases the resisting power of the body to the poisons of certain diseases—such, for example, as septic fevers. I am aware that laboratory experiments[1] have shown that rabbits in a state of intoxication are actually less resistant than normal to certain organisms, such as the streptococcus of erysipelas, but the dose of alcohol administered was excessive; and to set against these results we have the clinical experience of good observers, such as Todd, who regard alcohol as being actually an antidote to acute erysipelas.

In some chronic diseases, such as diabetes, alcohol is used as a real food to replace a certain amount of carbohydrate in the diet, whilst in others it is chiefly its tonic influences on digestion which one seeks to obtain. We shall have occasion to study its uses in these different directions in detail in subsequent chapters.

[1] See Abbott, *Journal of Experimental Medicine*, i. 447, 1896.

CHAPTER XX

ALCOHOLIC BEVERAGES: SPIRITS AND MALT LIQUORS

BEFORE proceeding to the study of the alcoholic beverages in detail, it may be well to describe the different ways in which the amount of alcohol which they contain may be stated. This is all the more important as an inaccurate use of terms may lead to some confusion.

In this country the standard employed is usually what is known as **proof spirit**, and an alcoholic liquor is said to be so much above or so much under 'proof.' Proof spirit is a mixture of alcohol and water, which contains 49·24 per cent. of the former *by weight* (*i.e.*, 100 grammes contains 49·24 grammes alcohol[1]), and 57·06 per cent. by volume (*i.e.*, 100 c.c. contains 57·06 c.c. alcohol). 'The name *proof spirit* owes its origin to the practice in vogue during last century, of testing the strength of samples of alcohol by pouring them on to gunpowder and applying a light. If the sample contained much water the alcohol burned away, and the water made the powder so damp that it did not ignite; but if the spirit were strong enough the powder took fire. A sample which just succeeded in igniting the powder was called proof spirit' (Perkins and Kipping). Spirits are described as being *over proof* when they are stronger than proof spirit, and *under proof* when they are weaker. Thus, 20 over proof means that 100 volumes of the spirit contain as much alcohol as 120 of proof spirit, and 20 under proof means that 100 volumes only contain as much alcohol as 80 of proof spirit.

Instead of using proof spirit as the standard, it is more convenient to speak of the amount of alcohol as being so much *per cent.* The percentage may further be stated either in weight or in volume. Five per cent. of alcohol *by weight* means, strictly speaking, that 100 grammes of the liquid in question contain 5 grammes of alcohol; but more usually the expression is used for weight *in volume*—

[1] 100 grammes of proof spirit has a volume of about 110 c.c., for shrinkage occurs when water and alcohol are mixed.

i.e., 5 grammes of alcohol in 100 c.c. Five per cent. by volume means 5 c.c. in every hundred, and is equivalent to about 4 per cent. by weight.[1] The percentage of alcohol *by volume* in some of the commoner alcoholic beverages is roughly as follows:

Rum ..	43 per cent.	Port ..	25 per cent.	Hock ..	10 per cent.
Whisky ..	43 per cent.	Sherry ..	21 ,,	Claret ..	9 ,,
Brandy ..	43 per cent.	Champagne	10 to 15 per cent.	Bottled beer	7 ,,
Gin ..	37 ,,			Lager beer	4 ,,

Spirits.

Spirits are obtained by the fermentation of various saccharine substances, the alcohol and other volatile bodies produced being separated by distillation. It is this fact of their being the products of distillation which gives to spirits their high alcoholic strength, and distinguishes them from all other alcohol-containing beverages. Almost any substance capable of yielding a fermentable sugar may form the basis of fermentation. Amongst the substances most commonly used in this country are malted and unmalted barley, maize, rice, sugar, and molasses. In some parts of Europe, and especially in Russia, potato starch is largely employed for the purpose. All of these substances yield alcohol on fermentation, but in addition various bye-products make their appearance during the process, and it is to the presence of these that the characteristic flavour of the different spirits is due.

Thus, the bye-products of the fermentation of malted barley give rise to the flavour of whisky, those of molasses to the flavour of rum, and those of the grape to that of brandy. By means of patent stills the bye-products can be almost entirely separated from the alcohol with which they are mixed, and the result is an almost pure form of spirit, the origin of which can scarcely be told, for which reason it is called **silent spirit**. By suitable flavouring the artful manufacturer can make this the basis of almost any spirituous drink.

Amongst the bye-products of fermentation there are usually found alcohols which are higher homologues of ethyl alcohol—*e.g.*, propyl, butyl, and amyl, and to a mixture of these the term **fusel-oil** is often applied. There is some reason to believe that fusel-oil is the product of a later fermentation which takes place after the alcoholic fermentation is completed, and it appears to be produced in larger quantity at high temperatures than at low. We shall see immediately that fusel-oil and the other bye-products met with in spirits

[1] c.c. alcohol in 100 vols. × 0·8 = grammes in 100 vols.
Grammes alcohol in 100 vols. × 1·25 = c.c. in 100 vols.
,, ,, in 1 litre × 7 = grains per gallon (6 bottles).

have effects on the body in health and disease only second to that of the ethyl alcohol itself.

The annual consumption of all spirits in this country in 1890 was as follows :[1]

England	.. .. ..	½ gallon per head.
Ireland	.. .. ..	1 ,, ,,
Scotland	.. .. ..	1½ gallons ,,

WHISKY.

Whisky has been defined by the Chairman of the Inland Revenue Board as 'a spirit made from malt or malt and grain, and distilled in pot-stills.' In the United States Pharmacopœia it is described thus: 'A spirit obtained from fermented grain by distillation, and containing from 48 to 56 per cent. by volume of alcohol. It should be free from disagreeable odour, and not less than two years old.'

It is important to distinguish clearly between genuine 'malt whisky,' which is made in 'pot-stills,' and 'grain whisky,' which is prepared in 'patent stills.' The bulk of ordinary whisky as it reaches the consumer is probably a blend of these two, grain whisky usually predominating.

(*a*) **Malt whisky** is prepared from malted barley which is first carefully dried. In many Highland distilleries peat is used as the fuel for drying, and some of the characteristic flavour of such whisky is believed to be derived from the peat smoke. After being dried, the malt is made into a mash, and here, just as we shall see is true of beer, the nature of the water used seems to have some influence on the character of the final product, soft water giving the best result. The mash is then fermented much as in the making of beer, only the process is allowed to go on longer. When fermentation is complete, the fermented mash or 'wash' is distilled in the old-fashioned pot-still. This is the form of still which is by far the most commonly used in Scotch and Irish distilleries. It is made of copper, and the volatile products are condensed in a simple 'worm,' no attempt being made to separate the spirit from the bye-products. The still is heated over an open flame. This is a point of some importance, for it causes some of the sugary substances in the wash to become slightly charred, and there is produced in this way, amongst other things, the substance furfurol, the presence of which is one of the chief distinguishing characteristics of pot-still whisky.

The first product of the distillation is called *low wines*. These are

[1] Report of the Select Committee on British and Foreign Spirits. For fuller statistics see a paper read before the Royal Statistical Society on April 24, 1900 (summarized in *British Medical Jonrnal*, April 28, 1900).

redistilled, and yield (1) 'fore-shots,' (2) 'clean spirit,' or whisky, (3) 'feints'; the residue left in the still being the 'spent lees.'

The fore-shots and feints both contain much of the bye-products of fermentation, and are redistilled, the distillate being added to the clean spirit, or whisky.

It must be noted that no fusel-oil is obtained separately by this method of distillation, and the product consists of alcohol plus some of the bye-products of fermentation. The whisky thus produced has an alcoholic strength of from 13 degrees to 50 degrees over proof, but before bonding it is usually reduced in Scotland to 11 degrees and in Ireland to 25 degrees over proof.

The bye-products which it contains give it when young a raw, harsh and disagreeable taste, but after keeping for some years in wood it mellows greatly, and the harsher the taste when young, the more full flavoured the whisky when matured.

What the exact nature of the changes is by which the improvement which whisky undergoes in wood is brought about we do not yet fully know. This we do know, however, that the percentage of alcohol diminishes, 6 to 8 per cent. of proof spirit being lost by five years' storage. On the other hand, the fusel-oil does *not* seem to undergo diminution, in spite of frequent statements to the contrary.[1]

Irish pot-still whisky differs from Scotch in being prepared usually from a mixture of malted barley with unmalted grain (barley or maize), and the malt is not dried over peat. Otherwise the manufacture of the two is very similar.

(*b*) **Grain Whisky.**—This is the form of whisky most commonly distilled in England. It is made from a mixture of grains (barley, rye and maize), with just a sufficiency of malt to convert their starch into sugar. More important than this distinction, however, is the fact that it is distilled by steam and in a patent (Coffey's) still in such a way that the bye-products of fermentation (fusel-oil, etc.) are, to a large extent, separated from the ethyl alcohol. The result is that the raw product has much less flavour than young malt whisky, and is sooner ready to go into consumption. When run off the still it is almost colourless and has an alcoholic strength of 60 degrees over proof, but is usually diluted to 11 to 12 degrees over proof before bonding. It acquires a yellowish colour from being stored in old sherry-casks.

[1] See Dr. Bell's evidence before the Select Committee on British and Foreign Spirits, 1890-91. Allen, however, does not agree with this. He considers that some of the fusel-oil is converted into volatile ethers.

As regards the main differences between the two varieties of whisky, I would emphasize—

1. That patent-still whisky contains much less of the bye-products of fermentation (including fusel-oil) than pot-still whisky, and is therefore much purer.

2. That as a consequence of this patent-still whisky does not improve nearly so much on keeping as the other variety.

It follows from this that a young patent-still whisky is much better to drink than *young* malt whisky, but that the latter, when fully matured, has a fuller and pleasanter flavour than the former. It is absurd to object to grain whisky on the ground that it contains more fusel-oil than malt whisky, for just the reverse is the truth. After removal from bond, whisky is diluted—or 'broken down,' as it is termed in the trade—by the addition of water. The legal limit of dilution is 25 degrees under proof (42·7 per cent. alcohol by volume), and the majority of vendors may be trusted to take full advantage of the permission, so that the ordinary whisky sold in bottle is of this strength; indeed, of fifty-one samples of public-house whisky taken from all over the country, the strength was from 15 to 25 under proof in all but two instances.[1] In other words, we shall not go far wrong if we regard a glass of whisky as containing rather less than half a glass of absolute alcohol.

As already mentioned, most commercial whiskies are blends, and not the product of one distillery at all. Grain whisky is often used as the basis of the blend, a certain proportion of malt being added to give flavour. Even when the blend contains as much as 90 per cent. of grain whisky, it is often sold as 'genuine malt.' The public taste at present is certainly in favour of a mild-flavoured whisky, hence the large use of grain spirit in blends.

Potheen is the product of illicit stills, and, being usually made from molasses, has the characters of rum rather than those of true whisky.

Brandy.

If whisky be regarded as distilled beer, brandy may be spoken of as distilled wine.

The best brandy was originally produced in one of the richest wine districts of France (Département de la Charente or Cognac district). The quality varies with the character of the grapes, the best grapes yielding the variety known as Fine or Grande Champagne. This is the only genuine liqueur brandy. The

[1] Select Committee's report.

varieties known as Petite Champagne and Première Bois rank next to it. If sold pure, these constitute old Cognac, but a large amount of them is used for blending with inferior varieties.

In a good year six or seven bottles of wine should yield one bottle of brandy. When first distilled the spirit is devoid of colour and of a fiery character. When kept in cask it takes up colour from the wood and gradually becomes mellower. Improvement goes on for a long time, so that the older the brandy the better. After twenty or forty years it contains a considerable proportion of volatile ethers and aldehydes, to which some of the most valuable properties of brandy are to be attributed.[1]

While the above is the origin of genuine brandy, it must be admitted that very little of the brandy sold in this country is so derived. The greater part of it is really concocted in the Cognac district from 'silent spirit' coloured with burnt sugar and flavoured with œnanthine or various essences. Such a product is entirely different from genuine brandy, for it is quite devoid of those volatile ethers derived from wine which are so conspicuous in genuine Cognac, and to which, as we shall see, it owes most of the valuable results it is capable of producing in sickness.

The production of genuine brandy by the distillation of Spanish wines has recently been begun at Jerez and elsewhere, and the product is pronounced by competent authority to be fully equal, in regard to the amount of ethers present, to pure Cognac.[2] If this standard is maintained, Spanish brandy should have a great future before it. It is the possession of volatile ethers in large amount which mainly distinguishes brandy from whisky; as regards alcoholic strength, the two are about equal.

RUM.

Rum is usually produced by the distillation of fermented molasses obtained in the manufacture of raw sugar; the best varieties, however, are obtained by direct fermentation of the juice of the sugar-cane. The spirit contains bye-products of fermentation, which impart to rum its characteristic flavour. The chief of these is said to be ethyl butyrate, and a considerable proportion of the rum sold in this country is made from silent spirit flavoured with that substance.

[1] For the changes which take place in brandy by age see a paper by Rocques (ref. in *Analyst*, 1897, p. 38).

[2] See 'The Composition of Brandy,' by Sir Charles Cameron and Professor W. R. Smith, *Journal of State Medicine*, June, 1899.

Rum owes its dark colour to burnt sugar. When kept for some time, it improves greatly in flavour by the development of ethers. It usually goes into consumption at about the same alcoholic strength as whisky, or perhaps a little stronger.

GIN.

Gin (also known as Geneva—from *genièvre*, a juniper—Schiedam and Hollands) is obtained by fermenting a mash of rye and malt, and distilling and redistilling the product. Juniper-berries and a little salt, and sometimes also hops, are added in the final distillation, and the product is run off into underground cisterns lined with white tiles, where the spirit can be kept without colouring.

The chief seat of the manufacture of genuine gin is at Schiedam in Holland. Much so-called gin, however, is fabricated elsewhere out of silent spirit flavoured with salt, juniper-berries, turpentine, etc.

Gin is allowed to be sold with as low a proportion of alcohol as 35 under proof (37 per cent. alcohol by volume), but is usually imported at 14 to 15 under proof. It is thus one of the most dilute of spirituous drinks. Sweetened and diluted gin is sold under the name of *Old Tom*.

Whilst varying somewhat in alcoholic strength, all the spirits we have been considering agree in containing very little solid matter—less, indeed, than 1 per cent., gin being the poorest in this respect. They have also a very low degree of acidity, brandy standing highest, with 1 grain per ounce (reckoned as tartaric acid), while whisky and gin have only about 0·2 grain per ounce. They are all practically free from sugar, for which reason the introduction of special whiskies, etc., for diabetics is quite unnecessary.

LIQUEURS AND BITTERS.

This group of liquors may be regarded as consisting essentially of spirit sweetened with cane-sugar and flavoured with aromatic or other herbs or essences. It has been well said that they are chiefly the product of the alchemist and the convent. The proportion of alcohol in them is high, varying from 33 to 50 per cent or more by volume. The proportion of the other ingredients is shown in the following analyses of some of the most prominent members of the group, taken from König :

	Alcohol. By vol.	Alcohol. By weight.	Extract.	Cane-sugar.	Various Extractives.	Ash.
Absinthe	58·93	—	0·18	—	0·32	
Benedictine ..	52·00	38·5	36·00	32·57	3·43	0·406
Crême de Menthe	48.00	36·5	28·28	27·63	0·65	0·043
Anisette	42.00	30·7	34·82	34·44	0·38	0·068
Curaçoa	55.00	42·5	28·60	28·50	0·10	0·040
Kümmel	33·90	24·8	32·02	31·18	0·84	0·058
Angostura.. ..	49·70	—	5·85	4·16	1·69	0·068
Chartreuse ..	43·18	—	36·11	34·37	1·76	

The following is a brief description of the origin and constituents of some of the better-known liqueurs and bitters:[1]

Absinthe.—Made by macerating Alpine plants of the wormwood species with the root of anise and sweet-flag and marjoram leaves in 40 per cent. spirit. A glassful (30 c.c.) contains the following amounts of absolute alcohol:

Ordinary absinthe	14·3 c.c.
Demi-fine	15·0 ,,
Fine	20·4 ,,
Suisse	24·2 ,,

The essential oil of wormwood is a convulsive poison.

Curaçoa.—Made in Amsterdam from the rind of bitter oranges grown in the island of Curaçoa.

Kirsch.—Made from cherries in the Black Forest.

Noyau.—Made from the *stones* of cherries, containing oil of bitter almonds.

Maraschino.—Made by fermenting a small sour cherry (*marasca*) grown in Italy and Dalmatia. Both the cherries and the stones are crushed and 10 per cent. of honey added, and the whole fermented. The spirit is diluted, and kept for some months to mature.

Kümmel.—Consists of brandy flavoured with cumin and coriander.

Vermouth.—Chiefly made in Turin from white wine flavoured and rendered bitter with Pontic wormwood and orange wine, and sweetened by the addition of 20 per cent. of sugar.

Chartreuse.—Made at the chief Carthusian monastery, near Grenoble, in France, and also at Florence. It contains a large proportion of sugar, the flavour being derived from various oils contained in angelica, hyssop, nutmeg, peppermint, etc.

Benedictine is a very similar product, made at the Abbey of Fécamp.

Angostura is now chiefly made at Trinidad, but formerly at Angostura, the chief flavouring ingredient being the bark of that name, though other spices are also added.

[1] For this description the author is largely indebted to Simmonds' 'Popular Beverages of Various Countries,' London, 1888.

Ratafia is a name now applied in France to various liqueurs made from spirit, sugar, and aromatic herbs. It derived its name from the fact that it used to be drunk at the ratification of compacts and bargains.

ACTION AND USES OF SPIRITS.

The **action of spirits on digestion** is practically identical with that of pure alcohol. They can only delay digestion in virtue of the alcohol which they contain, and then only in intoxicating doses. In moderate quantity their influence is probably favourable rather than otherwise, just as is that of alcohol itself. Their acidity is so slight that they have but a small effect on salivary digestion.

Liqueurs taken at the end of a heavy meal may perhaps give a fillip to digestion, and counteract to some extent any retarding influence of coffee taken at the same time, but the large quantity of sugar which they contain makes them irritating to an empty stomach and possible causes of acidity.

In studying the **general action of spirits** on the body, one must distinguish carefully between the action of the alcohol itself and that of the bye-products of fermentation which occur along with it. It would be a great mistake to regard spirits as simply mixtures of alcohol and water in nearly equal proportion.

Their high alcoholic strength renders all forms of spirits valuable stimulants where the action of alcohol pure and simple is desired. For such a purpose whisky is as good as any other, and pot-still or malt whisky possesses no real advantages other than flavour over the patent-still or grain spirit.

In cases of profound nervous and cardiac exhaustion, on the other hand, especially if delirium is present, one does not want merely an action upon the heart, but that stimulating influence upon the brain and vital centres which the volatile bye-products seem to be alone capable of exerting. Pot-still whisky, rum, and genuine brandy possess these bye-products, and especially those of an ethereal nature, in largest proportion, and therefore are much to be preferred in such a case. It is important, however, that these spirits should be old and well matured, for it is only then that they become really rich in ethereal bodies, and, of the three, genuine liqueur brandy is far the best.[1] In a case presenting signs of profound nervous and cardiac prostration the best liqueur brandy should alone be employed, no matter how much one has to pay for it. There can be no doubt that its free and timely administration has saved many lives.

[1] See Anstie, 'On the Uses of Wines in Health and Disease,' p. 44, and Murray, 'Liqueur Brandy' ('Rough Notes on Remedies'), third edition, p. 135.

'It is when our patient is far beyond the region of controversy, and life itself is "in the balance," that I find a sphere of marvellous usefulness for the best liqueur brandy, or, in lieu of it, very old cognac. Brandy, or even whisky, where the alcohol has been changed by age and original quality into vinous and ethereal spirit, is almost a pure stimulant, and hardly an intoxicant or narcotic at all. . . . Low forms of bronchitis and congestion of the lungs, the extreme exhaustion of some forms of influenza, the later stages of typhoid, cases of worn-out stomach from gastric catarrh, cases of breakdown from overwork, etc., all of them characterized by weakness of heart, failing circulation, inability to take food, loss of the power to sleep, and exhaustion, come into the category of suitable cases' (Murray).

Spirituous liquors are too highly alcoholic for ordinary dietetic use unless taken in great moderation and freely diluted. Two or three glasses of whisky or brandy contain as much alcohol as most people can safely consume in one day. If this limit be observed, however, and the spirit freely diluted, they may agree well, owing to their almost complete freedom from sugar or acids.

It is of interest to inquire at this point what constitutes the difference between a good and a bad spirit. Why, for instance, does a crude whisky produce headache, furred tongue, and derangement of digestion, while a well-matured spirit has no such effects? and why does one produce sudden and almost maniacal intoxication while another does not? Much as this question has been discussed, it must be confessed that no satisfactory reply to it is yet forthcoming. One may wade through the evidence given by experts before the Commission on British and Foreign Spirits and find nothing but confusion and contradictory statements.

The public have a general notion that the bad effects of immature spirits are due to the presence of fusel-oil. Let us inquire into this for a moment. We have seen that 'fusel-oil' is really a mixture of alcohols of higher boiling-point than ethyl alcohol. The exact nature of these alcohols varies with the source of the distillate. In brandy and patent-still whisky propylic alcohol is the chief one present; the fusel-oil of malt whisky and rum consists mostly of butylic and amylic alcohol. Now, experiments have certainly shown[1] that these higher alcohols have a much greater toxic action than ordinary ethyl

[1] See Dujardin Beaumetz, 'L'Hygiène Alimentaire'; Richet's 'Dictionary of Physiology,' article 'Alcohol'; and Binz's 'Lectures on Pharmacology,' I. 347; also Baer, *Archiv. f. Anat. und Physiol.*, 283, 1898 (Phys. Abth.), and Jeffroy and Serveau, *Archives de Méd. Expér.*, ix. 681, 1897.

alcohol. But even in a bad whisky there is not more than $\frac{1}{10}$ per cent. of fusel-oil present (about a grain to the glassful), and by experiment it is known that at least 1 per cent. is required to produce any marked effects. Further, the effects of fusel-oil have been put to direct tests in the human subject. King Chambers[1] says that he gave fusel-oil to various people in doses of from 1 to 10 drops, with the result of producing feverishness, furred tongue, throbbing of the temples, and headache; but other observers failed to get these results. Allen,[2] for instance, swallowed for a month considerable quantities of whisky to which he had added as much as 2 per cent. of fusel-oil without experiencing any bad results. Mr. Samuel, F.C.S., stated before the Commission on Spirits that he had consumed 4 ounces of brandy a day for four days containing $\frac{6}{10}$ per cent. of fusel-oil, and found no bad effects from it. This quantity was equivalent to 24 ounces of ordinary brandy with $\frac{1}{10}$ per cent. of fusel-oil. Finally, Zuntz[3] stated that when a controversy about fusel-oil was raging some years ago he gave patients considerable doses of it in capsule, and never observed any bad symptoms in the form of indigestion, headache, etc.

When we add to these results the fact that it is by no means clearly proved that old whisky is poorer in fusel-oil than young, it must be admitted that one can no longer regard the traces of higher alcohols in spirits as being responsible for the bad effects which these liquors sometimes produce. One is consequently confined to the supposition that the offending material is to be found amongst the other bye-products of fermentation, possibly in a volatile oil, while the local irritating effects of immature spirits on the stomach may be due to furfurol or some other empyreumatic body.

As regards the greater intoxicating effect of crude spirits, it must be pointed out that these may be due to the quantity and not to the quality of the liquor consumed, for spirits lose a considerable proportion of alcohol when stored in wood. Binz has made the ingenious suggestion that some of the volatile ether, produced in old spirits by oxidation, act as correctives to the action of alcohol, much as atropine does to morphia, but of this there is as yet no experimental proof.

MALT LIQUORS.

This group includes beer or ale, and porter or stout. There is some confusion in the use of these names, and they have not quite

1 'Manual of Diet in Health and Disease,' p. 78.
2 *Journal of the Society of Chemical Industry*, April 30, 1891.
3 *Deut. Med. Wochensch.*, No. 20, 1893.

the same meaning in all parts of the country. In some places the term 'ale' is applied to the brown beverages, while the black drinks are spoken of as 'beers.' It is better to regard the terms 'ale' and 'beer' as synonymous, and to apply them to the paler liquors, and to speak of the blacker drinks as stouts or porters. There is some reason, however, to believe that ale and beer were not originally identical, but that the former term was the earlier, 'beer' being only employed subsequent to the introduction of hops.

Beer may be defined as the product of the fermentation of malt and hops. We shall see later that much of the 'beer' in common use has not, strictly speaking, quite this origin.

Malt is obtained by moistening barley and allowing it to germinate in heaps at a moderate and regular temperature. During germination important changes take place: the ferment diastase appears in the grain and acts upon some of the starch, converting it into dextrin and malt-sugar, while part of the proteids, by the action of another ferment, is also converted into soluble forms. The 'green malt' so produced is next dried, and upon the exact temperature at which this is carried out the character of the beer largely depends, for the lower (within limits) the temperature employed, the more powerful is the action of the ferments contained in the grain, and the larger the amount of soluble substances produced. Low-dried malts produce pale beer; those dried at a higher temperature yield a darker product.

When drying is complete, the malt is ground and made into a mash with water. Rather hard waters yield, for some reason, the best beer, the water of Burton-on-Trent being apparently specially well suited for the purpose, and, indeed, in most breweries the water is artificially made up to the standard of that locality.

No stage in brewing has a greater influence on the quality of the beer than mashing. The higher the temperature at which it is carried out, the larger is the amount of malt sugar produced in the wort, while low temperatures yield a larger proportion of dextrin. After mashing, the wort is strained off from the malt and boiled for an hour or two with **hops**. Boiling stops any further action of the diastase, and extracts from the hops their soluble ingredients. Chief amongst these are tannic acid and certain resinous bodies of bitter taste. A substance called 'hopein,' the nature of which has not been fully investigated, but which seems to have properties resembling those of morphia, is also extracted. 'Lupulin,' which is the secretion of the glands of the hop, does not seem to be present in the finest varieties. The boiled wort is next pumped out and

rapidly passed over coolers, and is then ready for the addition of the yeast. Great care is now taken to employ pure yeast, for many of the diseases of beer, such as the development in it of acetic acid, are due to contamination with 'wild' yeasts. Scientific brewing has made great progress in this direction in recent years. The yeast is added to the wort in vats, and fermentation is then allowed to proceed. Here, again, much depends upon the temperature employed. In this country fermentation is usually conducted at rather high temperatures, with the result that most of the sugar is broken up and the resulting beer is rich in alcohol. In Germany lower temperatures are employed, and more sugar and dextrin are left in the beer, but less alcohol is produced. Low-fermentation beers also contain more carbonic acid than most English beers, and are therefore better aerated.

When fermentation is complete, the yeast, which has been carried to the surface, is skimmed off, and the beer is allowed to stand in shallow tanks till most of the remaining yeast has settled to the bottom. It is then run off into casks. Here a secondary fermentation occurs under the action of the small quantity of yeast still contained in the beer, but it is restrained to some extent by the addition to the cask of an extra quantity of hops. The longer this lasts, the greater is the amount of alcohol produced, and if strong beer is desired it must be left in the cask for some months. At the same time some volatile bodies seem to be developed which impart to such beer its full flavour, while the production of more carbonic acid under pressure leads to partial solution of that gas, and gives to the liquor a pleasant sharp taste. Just before bottling a solution of isinglass in acetic or tartaric acid ('finings') is added to the cask, which soon settles down in the form of a precipitate, carrying with it any remaining yeast cells and other impurities.

After bottling, the beer becomes brisker than it was in the cask, probably because no gas can now escape from it. Strong beer will keep well in bottle for eighteen months.

The taste for strong, full-flavoured ales seems now to be passing away, and a weaker and milder beverage is more largely produced, which, from the rapidity with which it goes into consumption, is termed 'running ale'; carbonic acid is often added to it by artificial aeration, and in order to insure its keeping an antiseptic is frequently added, especially in hot weather. Sulphite of calcium is largely employed for the purpose. It falls down quickly in the form of sulphate and does no harm. Salicylic acid is also used, but as not more than ½ ounce is usually added to a 36-gallon cask, it may be

regarded as quite innocuous. It is apt, however, to affect the flavour of the beer to some extent.

The names applied to different beers vary in different breweries, and many of the commercial brands are made by the judicious blending of beers produced in different ways. One can distinguish broadly between **mild** and **bitter ales**, the former containing relatively more malt and less hops than the latter, while in mild the malt is also dried at a higher temperature.

Indian Pale Ale is so called because it was first produced for the Indian market. It is very thoroughly fermented, and contains, therefore, but little sugar, and being highly hopped it has good keeping properties, for the hops act as an antiseptic.

The 'palatefulness' of ale depends partly on the actual amount of solid matter (sugar and dextrins) which it contains, and partly also on the nature of these bodies. The higher-priced ales usually contain more solid matter—*i.e.*, have a higher 'gravity,' and are more hopped than the cheaper sorts. A good ordinary 'bitter' has usually about 18 or 19 pounds of solids to the barrel, while ordinary mild ale has only 16 or 17 pounds. A really good bitter will have about 22 pounds, and Bass bitter as much as 23 pounds to the barrel. A barrel contains 36 gallons.

In an ordinary public-house the varieties usually distinguished are 'four-ale' (*i.e.*, 4d. per quart), which is the poorest; 'six-ale' (6d. per quart), which is a mixture of mild and bitter and comes next; and after that 'bitter' and 'Burton,' the last being the strongest of all.

The description of brewing given above applies only to 'pure' beers—that is to say, to beverages brewed only from malt and hops. A very large proportion, however, of the beer in ordinary consumption has not this origin, some cheaper source of sugar than malt being employed. Amongst the substitutes so used are invert sugar, potato glucose, flaked maize and rice; and the liquor produced from them is sometimes termed **substitute beer**.

A large amount of evidence concerning the production of these beers and their effects upon health was given before a recent Parliamentary Commission, but it must be admitted that the results were not very definite or satisfactory. It would appear that it takes an expert to tell the origin of a beer from its flavour, and it was certainly not clearly shown that the 'substitute' beers are really injurious to health, while they can undoubtedly be produced more cheaply than the genuine article.

Porter or **stout** is made in the same way as beer, but the malt is

first roasted in cylinders, much as coffee is. This has the effect of producing some caramel, to which the dark colour of these beverages is mainly due, and it must also, by killing the diastase, prevent the further production of dextrin and sugar in mashing. The proportion of solid matter in the liquor is often enhanced by the artificial addition of caramel or of invert sugar.

German beers, as has been mentioned, are fermented at a lower temperature than those of this country, and contain more dextrins. Secondary fermentation takes place in them to a large extent, and produces much carbonic acid gas. The peculiar flavour of Bavarian beers is said to be derived from pitch in the wood of the barrels.

COMPOSITION OF MALT LIQUORS.

The most important constituents of these beverages are alcohol, dextrins, sugar, and a small amount of soluble nitrogenous matter (together these make up the 'extract'), and vegetable acids.

The following table[1] gives the approximate composition of some of these beverages:

	Water.	*Alcohol. Per cent. by vol.*	*Total Extract.*	*Proteid.*	*Sugar.*	*Dextrins.*	*Acidity as Lactic Acid.*	*Ash.*
Bavarian winter beer	91·81	3·21	4·99	0·81	0·44	2·92	0·116	0·20
Bavarian summer beer	90·71	3·68	5·61	0·49	0·87	4·39	0·128	0·22
Munich Hofbräu	—	3·70	5·87					
Spatenbräu ..	—	3·23	6·61					
Pilsener.. ..	91·15	3·46	4·97	0·37	—	—	0·16	0·20
Munich Bockbier	88·72	4·07	7·23	0·71	0·90	—	0·17	0·27
English ale and porter.. ..	89·1	4·89	6·03	0·53	0·84	—	0·31	0·31
Berlin white beer	—	3·91	4·85					

The following is an analysis of Burton pale ale by Chittenden and Mendel[2]:

Alcohol	4 to 5·25 per cent. by vol.
Extract	4·4 ,, ,,
Ash	0·35 ,, ,,

The composition of two good specimens of stout is thus given by the *Lancet*[3]:

	'Oat Stout.'	'Nourishing Stout.'
Extract	6·3 per cent.	8·0 per cent.
Alcohol by vol. ..	6·24 ,,	6·55 ,,
,, by weight ..	5·0 ,,	5·25 ,,
Acidity	0·90 ,,	
Ash	0·45 ,,	0·33 ,,

[1] From Leyden's 'Handbuch der Ernährungs Therapie,' i. 105.
[2] *American Journal of the Medical Sciences*, p. 177, 1896.
[3] August 7, 1897, and May 21, 1898.

Chittenden and Mendel's analysis of Guiness's Dublin Stout is as follows:

Alcohol (by vol.)	5·5 per cent.
Extract	5·42 ,,
Ash	0·36 ,,

It has been calculated that the chief ingredients of a pint (20 ounces) of good average bottled beer are these:

Alcohol	1 fluid ounce.
Extract	1 to 2 ounces.
Free acids	25 grains.
Salts	13 ,,

ACTION AND USES OF MALT LIQUORS.

1. **Action on Digestion.**—Malt liquors have but little retarding influence on salivary digestion, and what action they do possess is entirely due to their acidity. Stout is twice as acid as beer, and hence has a greater retarding action on the digestion of starch by the saliva.[1] Sound beer, indeed, in some experiments,[2] seemed actually to increase rather than restrain the action of ptyalin, but sour beer has a decidedly retarding effect.[3] On the other hand, in the living body the bitterness of beer may bring about a more profuse flow of saliva, and so end by improving rather than impairing salivary digestion.

In the stomach beer does not remain, if taken alone, any longer than water, for 200 c.c. are found to have completely left it in about one and a half hours. If taken with other food, it delays the chemical processes of digestion more than the mere amount of alcohol which it contains will explain. Some[4] have blamed the 'extract' for this, others the salts;[5] but the action is, in any case, not an important one, for even half a litre of beer (about a pint), when taken with a mixed meal, was found to produce but very little delay in the stomach.[6] It is probable, indeed, that a tumblerful of good, brisk beer may actually aid digestion by increasing appetite and calling out a more abundant secretion of gastric juice and more active movements of the stomach.

Malt liquors seem sometimes to give rise to 'acidity' in the stomach. This may, perhaps, be the result of acid fermentation of the liquor, especially if it has not been kept very long in the cask.

[1] Chittenden and Mendel, *op. cit.*
[2] Aitchison Robertson, *Journal of Anatomy and Physiology*, xxxii. 615, 1898.
[3] Roberts, 'Digestion and Diet,' p. 119.
[4] Simanowsky, *Arch. f. Hygiene*, iv. 1, 1886.
[5] Buchner, *Deut. Archiv. f. Klin. Med.*, xxix. 537, 1881.
[6] Buchner, *op. cit.*

Beer is found by some persons to have an unfavourable influence on the liver, producing a sort of dyspeptic sluggishness. The way in which it does this is not fully understood, nor whether it is to be attributed to the malt or some ingredient of the hops. It is for this reason, amongst others, that beer is not a good beverage for the sedentary unless in very moderate amount. Stout is popularly believed to be more 'digestible,' and perhaps rightly, but bottled stout is an admirable soporific. 'If it be desired to avoid nervousness,' says Hutchinson, 'and to get rid of insomnia, shun tea and coffee, and drink Guinness's stout. . . . I scarcely ever met with a man who could withstand the soporific effects of bottled stout. It is far better than opium, and induces a more nearly natural sleep.' It is interesting in this connection to note that the residue of dried beer is found to have a sedative influence very much like that of morphia; this has been ascribed to 'hopein,' one of the soluble constituents of hops.

2. **Influence as Foods.**—The large quantity of carbohydrate matter in malt liquors renders them the most truly nourishing of alcoholic drinks. A pint of good ale contains as much carbohydrate as $1\frac{1}{8}$ ounces of bread.

I found the following amount of solids in some common varieties:

	Grammes in 100 *c.c.*
Pilsener Lager (Bremen)	2·7
Amsterdam Pilsener	4·1
Allsopp's Light Dinner Ale	5·2
Bulldog Stout	6·6
Bottled Lager (Bürgerbräu)	6·8
Nourishing Stout (Mountjoy Brewery) ..	9·2

According to these figures, an imperial pint of Allsopp contains 30 grammes of solid matter, and has in addition about 36 c.c. of alcohol. Together these will yield about 337 Calories of energy, and 2 pints will contain one-fifth of the total energy required daily. A glass of milk yields about 184 Calories, a similar glass of good bottled beer about 168. It does not follow from this, however, that beer is almost as good a source of energy as milk, for, as we have seen, alcohol is to be regarded as a food of only limited value. Five litres of good German beer with 5 per cent. of 'extract' should yield 250 grammes of carbohydrate (1,025 Calories), which is half the total required daily, and in addition 100 to 150 grammes of alcohol, with a fuel value of 700 to 1,050 Calories.

Malt liquors must be strictly forbidden in many forms of disease. The combined effects of their alcohol and carbohydrates render them specially prone to produce obesity, and they are also to be regarded

as frequent predisposers to gout. In all cases of inflammation of the mucous membrane of the genito-urinary tract, also, they seem, for some reason, to have a peculiarly bad effect, and the recurrence of a gleet, for instance, can often be traced to their use. They are too rich in carbohydrates to be suitable for any but the mildest cases of diabetes. Special beers are prepared, however, which contain very little extract and no sugar, and these can be safely recommended in cases of obesity or diabetes. Conspicuous amongst these is Harvey's sugar-free ale.

It must be remembered also that malt liquors are *bulky* drinks, and indulgence in them introduces a large amount of fluid into the circulation. The effort to expel this surplus fluid throws an extra strain on the heart, which may be very injurious if that organ is already damaged. In Bavaria a special form of hypertrophy of the heart ('beer-heart') is not uncommonly produced in this way, even in otherwise healthy persons.[1]

Some very good **non-alcoholic beers** are now manufactured, and may be conveniently mentioned here. Best known of these is Kops Ale, which contains about 0·7 per cent. of solids and less than ½ per cent. of alcohol. Other excellent preparations of the same class are Barrie's Bitter Beer[2] and the Banks Company's Ales. These possess the tonic and digestive actions of beer without its stimulating effects, and are a decided advance upon most 'temperance' beverages.

[1] See Von Strümpell, 65ten Versamml. deut. Naturforscher zu Nürnberg, p. 97, 1893.
[2] G. and P. Barrie, Albert Street, Dundee.

CHAPTER XXI

ALCOHOLIC BEVERAGES (*continued*): WINES[1]

WINE may be defined as *a beverage produced from the pure juice of the grape by fermentation.* Some add to this definition the saving clause, 'or with such additions only as are believed to improve its durability.' The quality of the wine depends very much upon the variety of the grape, the soil upon which it is grown, the mode in which it is cultivated, and the climatic conditions of particular years. The juice is obtained by crushing the grapes, treading being the method usually employed in order to avoid squeezing the stalks and stones too much, and so extracting undesirable ingredients.

The chief **chemical constituents of the juice** are sugar, albuminous matters and certain acids, of which the most abundant are tartaric and tannic acids. The sugar is a mixture of grape-sugar, or dextrose, and fruit-sugar, or lævulose, in the proportion of about three parts of the former to one of the latter.

The relative amount of albuminous matter and sugar in the juice has much influence on the character of the wine produced. The yeast lives upon the albuminous matter, and splits up the sugar, with the formation of alcohol and other products. If there be but little sugar and much albuminous matter present, the yeast can go on growing until all the sugar is split up. The wine will then be 'dry' and of an acid taste. Such a wine is hock. If, on the other hand, the sugar is out of all proportion to the albuminous substances in

[1] In obtaining material for this chapter, the author has been much indebted to the following, among other, publications: Thudichum and Dupré, 'A Treatise on the Origin, Nature and Varieties of Wine,' London, 1872; Thudichum, 'A Treatise on Wines,' Bohn's Scientific Library, 1896: in the preface references will be found to most other modern works on the subject; Gautier, 'La Sophistication des Vins,' 1884; Mulder, 'On the Composition of Wines' (edited by Bence Jones), 1857; Dupré, 'What is Wine?' (*Popular Science Review*, vol. vii.); Windisch, 'Die Chemische Untersuchung und Beurtheilung des Weines,' Berlin, 1896; Anstie, 'On the Uses of Wines in Health and Disease,' Macmillan and Co., London, 1877. References to other papers will be found in the text.

the juice, a limit is set to the growth of the yeast, and some sugar will be left in the wine, and it will then taste sweet. Should, however, the sugar and albuminous matter be present in more equal amount, the wine will retain some of both, and, though not sweet, will not have a distinctly acid flavour either, and will be of full 'body.' Such a wine is burgundy. It must be remembered, moreover, that no matter how much albuminous substance and sugar the juice may contain, the production of alcohol cannot go on indefinitely, for the accumulated alcohol ultimately ends by paralyzing the yeast. This takes place when the proportion of alcohol in the fermenting liquid has reached about 16 per cent. by volume. Hence it is that a 'natural' wine can never contain more alcohol than this; indeed, there is rarely so much sugar present in the juice as to allow of its containing so much.[1] If a wine contains more than 16 per cent. of alcohol by volume, one may be quite sure that spirit has been added to it artificially; that is to say, it has been 'fortified.' Sherry and port as sold in this country are always 'fortified' wines; claret and hock, on the other hand, are 'natural' wines.

The **colour** of red wines is due to a pigment contained in the skins of the grapes, which is turned red by the acids of the juice. As the skins are left in the vat in making such wines, the alcohol which is produced gradually dissolves out this pigment, and so the wine acquires its red or purple tint. The colour of the white or brown wines is mainly due to the oxidation of tannic acid in the cask.

The **yeast** which adheres to the skin of the grape, and which is responsible for the fermentation of wine, is different from the yeast which produces the fermentation of malt liquors or spirits. Further, we now know that the characteristic qualities of different wines are due, in some measure at least, to the fact that they are produced by different species of yeasts. Thus, the yeast concerned in producing hock is different from that which produces claret, and by growing a hock yeast on a claret 'must' one gets a wine which is, as it were, a cross between claret and hock, and has some of the distinctive characters of both. Bacteriology has in recent years come to the aid of the wine-producer, and by producing pure cultures of the different yeasts will shortly, no doubt, make wine production a much more scientific and certain process than it has hitherto been, and we may perhaps look forward in the future to tasting varieties

[1] In order to produce 16 per cent. of alcohol in the wine, there must be 34 per cent. of sugar in the juioe, while the usual proportion of sugar in the juice of most grapes is only from 13 to 30 per cent.

of wine hitherto quite unknown. I have already pointed out that the bacteriologist, by working on similar lines, has already done this for cheese.

The exact details of the process of fermenting grape-juice in order to produce wine from it vary considerably in different countries and localities, and little would be gained by attempting a description of them. As a rule, the first fermentation lasts for from two to six weeks, depending largely upon temperature, and the wine is left upon the lees till the spring, when it is siphoned off for storage. Prior to being placed in the cask, it is 'racked' by the addition of isinglass or white of egg, much as beer is by 'finings,' in order to remove albuminous matters (which prevent the wine from keeping) and suspended impurities. When clear, it is again 'racked' off from the deposit, and stored in casks in the cellar.

In the cask many very important changes take place to the occurrence of which the ultimate character of the wine is largely due. For one thing, the alcoholic strength of the wine rises. This is due to the fact that the water of the wine soaks into the wood more than the alcohol does, and is lost by evaporation, so that the wine becomes more concentrated. As the water so lost is replaced by the addition of more wine, the increase in the proportion of alcohol is rendered all the greater. In the cask, too, a partial oxidation of the tannic acid takes place. This causes the white wines to become darker in colour, but has just the reverse effect upon the red wines; for the oxidized tannic acid unites with, and carries down, some of their pigment.

The small quantity of yeast which always finds its way into the cask produces a slow secondary fermentation of the wine, which often lasts for years. As a result of this, some of the remaining sugar is converted into alcohol, and in this way also the alcoholic strength of the wine is increased. As the proportion of alcohol rises, some of the ingredients of the wine, such as tannic acid and bitartrate of potash, become less soluble, and fall down in the form of a deposit. During this time also some of the alcohol is oxidized into acetic acid, and the formation of compound ethers takes place. The maximum quantity of these, however, is usually reached in about five years, for the presence of water prevents the formation of ethers continuing till all available acids are used up.

After bottling, the formation of ethers still goes on, possibly with the aid of micro-organisms, but the alcoholic strength of the wine does not increase. It is quite a mistake to suppose that wine which has been kept long in bottle is necessarily stronger than a younger

wine. The reverse is the truth; for the alcohol seems actually to diminish after the wine has been bottled some years. It is also an error to suppose that wine goes on improving indefinitely. Like all other organic things, it is liable to decay by the slow processes of oxidation, and few wines really improve after thirty years; many, indeed, such as clarets, are at their best long before this, and it is only a few of the stronger wines, such as sherry and madeira, which will stand keeping for fifty, or possibly even a hundred, years.

CONSTITUENTS OF WINE.

The following is a list of the principal constituents found in grape-juice, or 'must,' and in the wine produced from it (Dupré):[1]

'Must' contains:	*Wine contains:*
Water.	Water.
Grape-sugar, Fruit ,, } 10 to 30 per cent.	Grape-sugar, Fruit ,, } 0 to 6 per cent.
Malic acid.	Ethylic alcohol, 5 to 22 per cent.
Tartaric acid.	Propylic ,,
Racemic acid.	Butylic ,,
Albuminous substances.	Amylic ,,
'Vegetable mucus.'	Other higher alcohols.
Essential oils.	Malic acid, Tartaric acid, Racemic ,, Succinic ,, Acetic ,, Formic ,, Propionic ,, Butyric ,, } 0·3 to 0·8 per cent.
Extractives.	Ethers of foregoing alcohols and acids.
Mineral substances.	Glycerine.
Tannic acid, Colouring matters, Fatty substances } from the skins and kernels.	Aldehyde.
	Carbonic acid and ammonia.
	Trimethylamin.
	Oils produced by fermentation.
	Albuminous matter.
	'Vegetable mucus.'
	Colouring matter.
	Tannic acid.
	Essential oils.
	Extractives.
	Mineral matters, 0·15 to 0·6 per cent.

It will be realized from this what a very complex fluid wine is. 'It is a profound mistake,' says Dujardin Beaumetz, 'to regard wine as a mere mixture of alcohol and water. It is a complete living entity, if I may so say, of which all the elements constitute an *ensemble* so complex and homogeneous that we cannot modify one or another without producing profound changes in the composition of the wine itself. . . . Wine has its youth, its maturity and its old

[1] 'What is Wine?' (*Popular Science Review*, vol. vii.).

age. Some vintages, such as burgundy, have a short life, and become prematurely old; others, like claret, have a much longer life, and are even sent on a voyage to hasten their maturity. Wines, too, have their diseases—diseases which usually result from imperfect manufacture and bad fermentation, leaving in them impure products.' The amounts of the chief solid constituents in 1 litre of wine are roughly these (Gautier[1]):

Water	718 to 935 parts
Glycerine	4 ,, 10 ,,
Colouring matter	0·6 ,, 1·5 ,,
Tartrates	1 ,, 3·75 ,,
Total solids	14 ,, 90 ,,

Ordinary Rhine and French wines have about 2 per cent. of solids; port has about 5 per cent. It would serve no good purpose, however, to give an analysis of wines in detail, for, after all, the information which chemistry can give us about wines is of limited value. It can tell us, it is true, a good deal about those ingredients which have most influence upon health, but it cannot tell much about those volatile compounds to which the most highly-prized qualities of wine, such as flavour and bouquet, are due, and for which one chiefly pays in buying wine when, indeed, one is not merely paying for the label on the bottle.

I propose, therefore, to describe briefly the most important of the constituents which influence health, and afterwards to consider the chief characters of some of the commoner wines in detail.

1. *Alcohols.*—Wine contains several alcohols, ethyl alcohol, however, being by far the most abundant. Amyl, propyl, butyl, and other higher alcohols are present in traces, being derived chiefly from fatty substances contained in the skins and stones of the grapes. A hundred volumes of a natural wine may contain anything from 6 to 12 grammes of ethyl alcohol. If there is less than this, the wine tastes flat; if there is more, one may be almost quite certain that alcohol has been added artificially—*i.e.*, that the wine has been 'fortified.' The advantage of fortifying wine is that it enables it to keep better, subsequent fermentation being restrained, and the production of acetic acid prevented. It is often necessary in the case of wines produced in very warm countries, where fermentation cannot safely be allowed to go on to its full limits, owing to the danger of the growth of 'wild' yeasts and the production of acids. Fortified wines not unfrequently have as much as one-third of their volume of spirit added to them, and require to be kept for a long time in bottle,

[1] 'La Sophistication des Vins,' 1884.

in order to re-acquire a true vinous character. Partial sterilization of the wine by the process of 'pasteurization' is now often used to effect the same object as 'fortification.'

2. *Acids.*—The natural acids found in wine are tartaric, malic and tannic. Acetic, formic, succinic and other fatty acids are produced by fermentation along with carbonic acid.

Tartaric and tannic acids are the most important. The former occurs combined with potassium in the form of bitartrate of potash or argol. As the proportion of alcohol in the wine rises, the bitartrate becomes less soluble, and ultimately much of it falls out in the form of a crust of 'tartar.' Hence it is that wines become less acid on keeping. The form of tannic acid met with in wine is probably not identical with that of oak-bark. It is chiefly derived from the skins and stalks, and is therefore more abundant in red wines. It diminishes by oxidation on keeping, and in the mature wine is not present in any large amount; for even an astringent red wine has only about 2 grains in a 2-ounce glass, while an ordinary glass of claret (4 ounces) has not more than 1 to 2½ grains, or about as much as is contained in a cup of tea.

Acetic acid may be produced in wine by the growth in the 'must' of a special organism (the *Mycoderma aceti*), which, if unchecked, would ultimately convert all the wine into vinegar. It flourishes especially in very warm countries, and the necessity for preventing its growth is one of the reasons why the wines of such countries are so often fortified.

Acetic acid can also be produced by direct oxidation of the alcohol of wine in the presence of albuminous matter, and this occurs to some extent in the cask, and also in bottle, if any air finds its way into the wine through the pores of the cork. In order to prevent this, the bottle should always be laid on its side, so that the cork is kept soaked in wine.

In a sound wine the **total acidity** is not more than 0·3 to 0·7 per cent.; above this limit the wine will taste sour. It must be noted, however, that mere taste is no true indication of the acidity of a wine, for the sourness is much concealed by the presence of sugar. As a matter of fact, many sweet wines are quite as acid as the so-called sour wines.

Dupré found the following amount of acid (reckoned as tartaric) in one bottle of wine:

Claret	65 to 77 grains
Hock	57 ,, 70 ,,
Sherry	54 ,, 61 ,,
Port	49 ,, 62 ,,
Marsala	39 ,, 46 ,,

A sample of '47 port analyzed by Luff[1] had an acidity of 0·6 per cent., equivalent to 6 grains of tartaric acid in every wineglassful. He calculates that three-fourths of the total acid in two bottles of such wine would require to enter the circulation at one time in order to neutralize the alkalinity of the blood.

The **volatile acids** in wine (acetic, etc.) should not be present in a higher ratio than 1 to 3 of fixed acids (tartaric). If the proportion is higher than this, the wine is slightly 'turned'—*i.e.*, is on its way to become vinegar. Red wines usually contain rather more volatile acid than white.

3. *Sugar.*—The chief sugar found in wine is fruit-sugar, or lævulose. A 'natural' or fully-fermented wine should contain about ½ per cent. of sugar; if there is less than this the flavour is not pleasant. As a rule, therefore, natural wines are 'dry.' Sauterne is one of the few natural wines which is rather rich in sugar. 'Fortified' wines in which fermentation has been checked by the addition of spirit contain 2 per cent. of sugar or more, while the sweet wines may have as much as 20 per cent.

Dupré found the following amount of sugar in different samples of wine:

Hocks ..	..	1·4 to 8·6	grains per bottle.
Clarets ..	..	11 ,, 18	,, ,,
Sherries	..	217 ,, 421	,, ,,
Ports ..	..	121 ,, 519	,, ,,
Old marsala	..	388 ,, 451	,, ,,
Sauterne	..	125	,, ,,
Champagne	..	500	,, ,, down to almost none.

It will be evident from this that sugar can hardly ever be present in wine to a sufficient extent to be of influence as a *food*. Even a sweet wine with 4 per cent. of sugar will contain only about an ounce in a bottle, or pretty much the same quantity as a bottle of ordinary lemonade. As Anstie points out, it is hardly possible to take in more than ⅓ to ½ ounce of sugar daily in the form of wine without at the same time consuming so much alcohol as would produce intoxication.

4. *Ethers.*—These are produced by the interaction of the alcohols and acids contained in the wine. They are very numerous as regards variety, as can readily be imagined when it is pointed out that a wine containing five different kinds of alcohol and five acids may contain twenty-five ethers. Their actual amount, however, is always very small. The highest proportion Dupré found was in a fifty-year-old madeira, and even then there was only 1 part of ether in every 300 of wine.

[1] 'Gout: its Pathology and Treatment,' Cassell and Co., 1898, p. 145 *et seq.*

The ethers of wine may be divided into two classes: (1) volatile, (2) fixed. The former are produced by volatile acids, such as acetic; the latter by the fixed acids, such as tartaric. The volatile ethers predominate in natural wines, while most fortified wines contain the fixed ethers in greater abundance. To this rule, however, sherry and madeira seem to be exceptions, for they are often rich in the volatile class.

Acetic ether is usually the most abundant volatile ether met with in wine, but old wines may contain traces of aceto-propylic, aceto-butylic, aceto-amylic, aceto-caproic, and aceto-caprylic ether as well.

The ethers—and especially the volatile ones—are of importance as imparting to wine much of its 'bouquet,' and a rough estimate of their richness in any particular wine can be made by noting the distance at which the bouquet can be smelt. They also contribute in large measure to some of the most important therapeutic properties of wine, as will be explained later.

The substance **œnanthine**, or œnanthic ether, demands special mention. It is derived from a hypothetical fatty acid (œnanthic acid) contained in the stones, stalks, and skins of the grapes, and more especially, perhaps, in the waxy fat which gives to the grapes their bloom. This acid is not found by itself in wine, but only in the combined or ethereal form. There is not more than 1 part of it in every 40,000 of wine, but along with glycerine and succinic acid it is mainly responsible for the peculiar 'vinous' smell and taste characteristic of all wines in common.

5. *Extractives* usually make up the bulk of the solid matter in all wines, except such as are rich in sugar. They consist chiefly of carbohydrates, such as pectins and gums. They contribute to the taste and 'body' of the wine.

6. *Glycerine* is produced along with alcohol in the process of fermentation, and is always present in wine and in sufficient amount to affect the taste. It is usually said that it amounts to one-fourteenth of the volume of the alcohol; but that is not quite accurate, for different yeasts seem to produce it in varying amount, so that no definite ratio between glycerine and alcohol can be laid down.

Varieties of Wine.

Perhaps the most important division of wines is into (1) natural and (2) fortified. The **natural wines**, as already explained, are those in which fermentation has been allowed to go to its full limit—that

is to say, until the process is arrested spontaneously either by exhaustion of all the sugar and albuminous matter in the grape-juice, or until sufficient alcohol has been produced to prevent the further growth of the yeast. The latter consummation is reached when the fermenting juice contains 12 per cent. of absolute alcohol *by weight*, and natural wines, as defined by law, must contain less than that amount. **Fortified wines**, on the other hand, are those in which the process of fermentation has been artificially arrested by the addition of alcohol[1] either as 'silent' spirit, brandy, or some other concentrated form. Fermentation being thus arrested before all the sugar has been broken up, such wines are apt to be sweet, and are, of course, of comparatively high alcoholic strength.

Natural wines, on the contrary, are usually poor both in alcohol and sugar. The natural wines also, containing as they do a little acetic acid produced by prolonged fermentation, are rich in volatile ethers even in their youth, while the fortified wines, though they may ultimately contain much ether, only arrive at such richness in their old age, and the fixed ethers, except in the case of sherry and madeira, preponderate over the volatile. The distinction between natural and fortified wines is of further importance for this reason, that, as we shall see later, the natural wines are alone suited for habitual consumption as articles of diet, the fortified wines being rather to be regarded as medicinal agents.

The principal natural wines are claret and hock, and the Hungarian, Italian, Australian, and Californian wines. The chief members of the 'fortified' group are port, sherry, madeira, and marsala. Champagne and the Greek wines are also usually fortified.

Claret (probably derived from *clairet*, a thin *vin ordinaire*) is produced in the district of Médoc, the seaport of which is Bordeaux. It is a pure natural wine containing 8 to 13 per cent. of alcohol by volume, very little sugar (about ½ per cent.), and a moderate amount of acids, acetic acid being always present to some extent. It contains also a high proportion of volatile ethers. The best growths, or 'crus,' are Château Margaux, Lafitte, and Latour.

Haut Brion is a red wine produced in the neighbouring district of the Gironde, and resembles a burgundy rather than a médoc. Sauternes are white wines made in the same district, and usually contain a good deal of sugar, from the grapes being allowed to hang for a long time on the vines before they are picked. The famous

[1] In the case of some fortified wines, however, *e.g.*, sherry, the alcohol is added after fermentation is complete.

Château Yquem is the finest of all the white wines so produced. Thudichum states that brandy is sometimes added to the natural wines of Bordeaux: not that it is required for their preservation, but simply in order to suit the English palate.

Burgundy resembles claret, but is richer in extractive matter, and has therefore more 'body.' It is also of higher alcoholic strength. It is produced in the district of that name, the best part being that which stretches between Dijon and Chalon. The most esteemed varieties are Beaune and Chambertin. Beaujolais and Mâcon, though not really produced in Burgundy, are usually classed with those wines. Ordinary burgundy is made from black grapes, but Chablis is a white burgundy produced from white grapes grown in the same district.

Hocks derive their name from Hochheimer, on the right bank of the Maine. With the exception of that produced at Assmannshausen, they are all pale wines. They have about the same alcoholic strength as claret, and contain hardly any sugar, for which reason they are apt to seem rather acid. Their acidity, however, is not really higher than that of claret (about ½ per cent.), and they contain almost no acetic acid. They have the advantage of possessing a fine bouquet and extraordinary keeping qualities. The choicest varieties are those of Johannisberg, Steinberg, Marcobrun, Rüdesheimer, Rothenberg, and Hochheimer.

Hungarian wines are both red and white, and rank with claret and hock as the finest natural wines the world produces. Their alcoholic strength is about the same as that of the other two, but they are rather more acid. They resemble hock in being almost free from sugar. The finest variety, Tokay, is produced from grapes which have been allowed to dry on the stalks before being picked. It is a sweet wine of low alcoholic strength, and should have been kept very long in bottle. The special *Imperial Tokay* is one of the choicest wines known, but is never sold in trade. Some of the commoner dry Hungarian wines, both red and white, make excellent table beverages. They have rather more body than the corresponding wines of France, and a moderate degree of astringency.

Italian wines, both white and red, all belong to the 'natural' class. As a rule, they are of low alcoholic strength, but rather more acid and astringent than a light Bordeaux wine. Their acidity is rather high. The following analyses from the *Lancet*[1] represent the composition of some of the varieties more commonly sold in this country:

[1] January 28, 1899.

	Capri (White).	Falerno (White).	Chianti (Red).	Barolo (Red).	Egidio Vitali (Sparkling White).	Valtellina (Red).
Alcohol by weight	11·62	8·64	9·36	10·85	10·08	9·36
,, ,, volume	14·37	10·73	11·61	13·43	12·49	11·61
Tartaric acid ..	0·52	0·66	0·60	0·45	0·79	0·41
Acetic ,, ..	0·31	0·13	0·18	0·25	0·26	0·29
Sugar	0·76	0·11	0·17	0·18	3·67	0·13

Californian wines, from a merely chemical point of view, compare very favourably with the corresponding wines of Europe, though they are undoubtedly not yet equal to the latter in the more æsthetic qualities. For natural wines, they contain rather a high proportion of alcohol, but relatively little glycerine. In the white varieties the extract, total acidity and ash are generally lower than in the corresponding European wines, while in the red sorts these ingredients are relatively higher than in the old-world wines. A careful investigation of them has been made by Krug,[1] who concludes as follows: 'On the whole, it is evident that the Californian dry wines are fully equal to the European wines, and the red wines are in every respect superior to the young French clarets. The sweet wines are to be unconditionally preferred to the European Southern wines, containing the same amount of alcohol and extract, and not being plastered.' Their chemical equality with European wines is also confirmed by the *Lancet*,[2] from which the following analyses are taken :

	A Californian Sauterne. Per cent.	*A Californian Hock. Per cent.*
Alcohol by weight	10·31	10·00
,, ,, volume	12·77	12·40
Extract	2·31	1·90
Ash	0·16	0·20
Total acids	0·69	0·67

The **Australian wines** resemble rather closely those of California, They are full-bodied natural wines, containing rather more alcohol than most clarets. They are chemically pure, and in recent years have improved very much in the finer characteristics of good wine, as the result of greater care in the cultivation of the grape.

The term **sherry** is applied to all the white wines of Spain, being derived from the town of Jerez, which may be regarded as the capital of the sherry-producing district. As drunk in this country. they are all fortified wines, containing from 15 to 22 per cent. of alcohol by weight. A 'natural' sherry is quite a possible product, but is never imported into this country on account of its being

[1] *Journ. of Amer. Chem. Soc.*, xvi. 597, 1894.

[2] July 7, 1894.

deficient in 'keeping' qualities. Sherries are also all 'plastered' wines; that is to say, sulphate of lime is sprinkled on the grapes after they are first trodden, in the proportion usually of 2½ pounds to every ton.

The practice of **plastering** is one of great antiquity, and was mentioned long ago by Pliny. It was first adopted, no doubt, empirically, and the advantages of it are still far from being fully understood, although all experienced sherry-growers are of opinion that without its aid the production of a wine having the special characteristics of sherry is impossible. It may be that it acts as a preservative against the 'viscosity fungus,' which is so much commoner in Southern than Northern wines (Thudichum).

The chief chemical effect of plastering is to decompose the bitartrate of potash in the 'must' with the production of insoluble tartrate of lime, sulphate of potash, and tartaric acid, according to the following equation:

$$2KHC_4H_4O_6 + CaSO_4 = K_2SO_4 + CaC_4H_4O_6 + H_2C_4H_4O_6.$$

The phosphates are also thrown down.

As the tartrate of calcium falls out, it clarifies the wine, carrying down with it albuminous matters and suspended impurities. The tartaric acid produced renders the wine redder, and increases its free acidity, so facilitating the production of ethers later on.

There is introduced into the wine as the result of plastering 0·3 gramme of sulphate of calcium per litre, and 1·2 grammes of sulphate of potash, much of it, probably, in the acid form. The sulphate of potash may cause sherry to be slightly laxative to some persons if freely drunk, and renders it also somewhat bitter, but it cannot be said to have any other bad effects. It has been said that it may be productive of cirrhosis, but of this there is no sufficient evidence, and, indeed, the employés in the Spanish bodegas are stated to drink as much as 10½ pints of light sherry daily, without suffering from any injurious effects.

The amount of sugar in sherry varies from practically nil in the driest sorts up to 4 per cent. in a very raisiny wine. The acidity is lower than that of the natural wines already considered.

Sherry develops in its old age a very large proportion of volatile ethers—more, probably, than any other alcoholic liquor, except a genuine cognac. To this property much of its value as a stimulant in disease is to be attributed.

Broadly speaking, there are **two classes of sherries**:

1. 'Fino,' a light, pale, delicate wine of Amontillado[1] or Manzanilla[2] type.

2. 'Oloroso,' a sweeter, full-bodied, brown wine. Intermediate between these is the class known as 'Palo Cortado.'

The following is an analysis of examples of these :[3]

	Amontillado. *Per cent.*	*Oloroso.* *Per cent.*	*Medium.* *Per cent.*
Solids	2·20	5·45	2·87
Sugar	0·215	1·03	0·65
Potassium bitartrate ..	0·08	0·26	0·13
Tartaric acid	0·34	0·52	0·41
Acetic ,, ...	0·12	0·20	0·10
Ash	0·55	0·86	0·70
Sulphate of potash ..	0·52	0·76	0·65
Alcohol by weight ..	14·82	18·85	15·67
,, ,, volume ..	18·25	23·10	19·28
Total ethers	0·06	0·21	0·075

Pure sherry may be regarded as a genuine grape product, for the substances added to it in manufacture are also derived from grapes. Thus, 'grape liquor' is used for sweetening, and the same, slightly caramelized, for colouring. The spirit added in fortification is also obtained by distilling fermented grape-juice.

Port is the wine produced in the district of the Upper Douro, and takes its name from the town of Oporto. The whole of the wine that reaches this country is fortified, containing from 15 to 20 per cent. of alcohol by weight. One of the chief peculiarities of port is the large amount of 'extract' it contains, which gives it a full body. Its acidity is not great, less, indeed, than that of hock, but it contains relatively more acetic than tartaric acid, for the latter is insoluble in the large amount of alcohol which port holds. It possesses a good deal of tannic acid, the stalks not being removed before fermentation, but this diminishes with age, though when young it is very rough and astringent. It is sweeter than sherry, containing from 2 to 6 per cent. of sugar, for it is fortified before fermentation is complete, not after it, as sherry is. Old port contains a large proportion of ethers, but, unlike sherry, the fixed ethers predominate over the volatile. When mellowed it has an excellent flavour and bouquet, and retains only a moderate amount of fruitiness.

Madeira is derived from the island of that name. For a long time the ravages of the phylloxera stopped the production of the wine, but in recent years the industry has begun to revive. The wine resembles sherry in its general characteristics and in the high pro-

[1] Amontillado = à la Mantilla (a town near Cordova).

[2] From Manzanilla, a town near Jerez.

[3] *Lancet*, October 29, 1898 (Report of Commission on Sherry, from which many of the statements in the above paragraphs are taken).

portion of volatile ethers which it contains. It is a fortified wine, containing from 17 to 20 per cent. of alcohol by weight.

Marsala is a Sicilian wine also resembling sherry, but sweeter and containing a much lower proportion of volatile ethers. It is only slightly acid.

Greek wines may be either natural or fortified, but usually contain only 8 to 14 per cent. of alcohol by weight. They are rich in volatile acids, and are peculiar, also, in containing some aldehyde. They are often plastered. Their chief defects are due to imperfections in the methods of manufacture.

Champagne is the wine produced in the Champagne district of France, the best varieties being obtained from the prefectures of Rheims and Epernay. It is produced, curiously enough, chiefly from black grapes. These are squeezed in a very powerful press, and the first pressings used to produce the finest wines. The character of the vintage in different years has also a very marked effect on the quality. The expressed juice, or 'must,' is allowed to stand for twelve hours in order to let all suspended matters fall out, and is then drawn off into casks to undergo the first fermentation. At this stage the different growths, or 'crus,' are blended to form the special 'cuvées,' the finest of which are only produced from the best grapes. The young wine is then bottled and left for two years, to undergo the secondary fermentation. The maintenance of a constant temperature is very important at this stage, and is attained at Châlons, Epernay, and Rheims, by storing the bottles in large cellars excavated from chalk cliffs. During this fermentation a large amount of carbonic acid gas is produced, and as the percentage of alcohol rises a considerable deposit falls down into the neck of the inclined bottle. This is fixed to the cork by freezing, and removed with the latter in the process of 'dégorgement.' The wine is still of a sour, harsh, or 'brut' character, and is made drinkable by 'dosage.' This consists in adding to it a solution of cane-sugar[1] dissolved in old champagne and good cognac. Upon the amount of dosage the sweetness or dryness of the wine depends. In this country we like champagne dry, and therefore only 2 to 4 per cent. of liqueur is added to the wine exported to England. For Russia, where a sweet wine is preferred, as much as 14, or even 16, per cent. of liqueur is used. The wines exported to the United States, Belgium and Germany receive an intermediate degree of treatment. There can be no doubt that the taste for a dry champagne is rewarded by

[1] The cane-sugar is gradually changed into invert sugar after its addition to the wine.

getting a purer wine, for heavy liqueuring covers many defects. Hence the dry wines are really the finest. It must be remembered, however, that unless 8 per cent. of liqueur has been added the quality of the wine will not be found to improve after longer than twenty years.

Champagne should, strictly speaking, be a natural wine, containing from 9 to 12 per cent. of alcohol by weight, but in recent years a taste for a stronger wine has grown up, and champagne as drunk in England is now mostly a brandied liquid (Thudichum). The amount of sugar varies from nil up to 14 per cent., depending on the dosage. The acidity is about 0·5 to 0·6 per cent.—*i.e.*, that of an average claret. A *dry* champagne contains about 2 per cent. of solid matter. A bottle of good champagne will contain about five volumes of carbonic acid gas. Four-fifths of this, however, is given off whenever the cork is drawn.

The following table from Dupré's analyses may be of use for the purpose of comparing the chemical composition of some of the wines just described. It must be remembered, however, that mere chemical analysis is only of limited use in judging of the quality of a wine:

Wine.	Grammes Absolute Alcohol.	Free Fixed Acid.	Free Volatile Acid.	Total Acid.	Sugar.	Dry Residue.	Ash.	Total Alcohol in Ethers.
Hock (three samples) ..	9·73	0·399	0·088	0·506	0·062	1·92	0·17	0·042
Claret (three samples) ..	9·68	0·390	0·167	0·599	0·243	2·124	0·21	0·038
Hungarian wine (three samples) ..	10·16	0·454	0·192	0·694	0·077	1·906	0·18	0·046
Greek wine (three samples)	12·35	0·342	0·215	0·611	0·225	2·507	0·30	0·048
Sherry (three samples) ..	17·80	0·286	0·161	0·487	3·015	5·06	0·50	0·061
Madeira (two samples) ..	17·82	0·373	0·247	0·680	1·85	4·44	0·37	0·096
Port (three samples) ..	18·11	0·309	0·09	0·434	2·54	5·34	0·23	0·053
Marsala (two samples) ..	16·8	0·206	0·12	0·361	3·50	5·36	0·26	0·049

The table gives weights of different ingredients in 100 c.c. To get grains per bottle multiply by 120.

Cider and perry, derived from the apple and pear respectively, may be conveniently considered here, for they are really to be regarded as wines; cider, indeed, when first made in England in the thirteenth century was always called 'wine.'

The finest English *cider* is made in Devon, Hereford and Somerset. The mid-season fruit, which ripens in October, is best for the purpose. It is gathered and allowed to mellow under cover for a fortnight, and is then ground to a pulp, the kernels being sometimes left out. The pulp is left in vats for thirty hours, and is then pressed, and 100 gallons of the liquor run into a clean vat and left for some days till it clears. It is then racked, clarified with charcoal and strained through bags, and the clear, bright liquid run into 100-gallon casks and bunged down.[1] Perry is made in a very similar way. If a 'sparkling' beverage is desired, fermentation is allowed to go on in bottle. The composition of these beverages seems to vary within rather wide limits. They are only mildly alcoholic, having 3 to 8 per cent. by volume, or much the same proportion as beer. Sugar amounts to 0·2 to 0·6 per cent. They are moderately acid (0·1 to 0·6 per cent.), the chief acid present being malic. The more acid varieties (0·6 per cent.) will have an acidity equal to about 22 grains of tartaric acid per tumblerful.

A sample of genuine Devonshire home-made cider which I examined had the following composition:

Alcohol (by volume)	6·0 per cent.
Solids	1·5 "
Total acidity	0·66 "
Volatile acidity	0·089 "

The following analyses are from the *Lancet*:[2]

	Cider.	*Champagne Perry.*
Alcohol by weight	2·70	1·45
" " volume	3·40	1·80
Solids	8·16	11·0
Ash	0·32	0·35

French and American imported ciders are thinner and weaker than the home-made article. Bottled cider has less alcohol (3 to 4 per cent.) and more sugar (2½ to 6 per cent.) than draught.[3]

Medicated wines are concoctions, the basis of which is port or sherry, to which has been added extract of beef, extract of malt, peptone, pepsin, coca leaves, cocaine, cinchona, iron, or some other dietetic or medicinal substance. A 'beef and malt wine' may usually be regarded as containing about 1½ ounces of extract of meat and 2 ounces of malt extract in a pint of 'detannated' port or sherry. For the medicinal wines there is no definite formula. Of the 'coca'

[1] Radcliffe Cooke, *Journ. of the Soc. of Arts*, March 8, 1895.
[2] October 1, 1892.
[3] Felix Aury, 'Le Cidre et le Poiré,' Thèse de Paris, 1894.

wines, some are made from coca leaves, others from liquid extract of coca, and some from hydrochlorate of cocaine.

The use of these wines can on no grounds be recommended. In the first place, they are not worth the price charged for them, for it is far cheaper and also better for an invalid to get beef or malt extract separately and take along with them, if need be, a definite quantity of sound wine of known antecedents.[1] In the second place, it is open to grave question whether the ferment of malt (diastase) is not much impaired by the action of the alcohol to which it is exposed when dissolved in a fortified wine, such as port or sherry.

The medicated wines are open to the same objection to an even greater extent. The use of such liquors by an invalid on his own responsibility, or even by prescription, exposes him to great danger of becoming by degrees the unconscious victim of alcoholism, and, in the case of the coca wines, of the cocaine habit as well. On every ground their manufacture and sale should be strongly deprecated by the medical profession.

Action and Uses of Wines.

Influence on Digestion.—Wines have a much more powerful inhibitory effect on salivary digestion than mixtures of alcohol and water of equal strength. Roberts,[2] for example, found that if even 1 per cent. of sherry or hock were present in the digesting mixture, the conversion of starch was almost brought to a standstill. This effect of wines is entirely due to their acidity. The experiments of Aitchison Robertson[3] showed that a claret of 0·75 per cent. acidity had a markedly retarding effect on salivary digestion, while the influence of a sherry of 0·54 per cent. and a port of 0·42 per cent. was very much less. Chittenden and Mendel confirmed these results. The inhibitory effect of wines is lost when their acidity is neutralized. Hence, it is an obvious advantage, from a digestive point of view, to mix the more acid wines with an alkaline aerated water, such as Apollinaris.

On *gastric digestion*, also, wines exert a retarding effect out of all proportion to the amount of alcohol they contain. The cause of this is not clear. According to some writers, it depends upon their solid ingredients. Roberts attributes it, in part at least, to some of the volatile constituents. Sherry and port seem to have a more powerful effect than claret or hock. Half a pint of sherry in

[1] See also Coley, *Brit. Med. Journ.*, September 10, 1898.
[2] 'Digestion and Diet,' p. 117.
[3] *Journ. of Anat. and Physiolog.*, xxxii. 615.

2 pounds weight of stomach contents is sufficient to produce a very pronounced degree of inhibition, and yet this is a not infrequent allowance. A pint of claret or hock is also enough to produce distinct effects. Effervescing wines, on the other hand, such as champagne, are much more feeble in their results, probably because the gas which escapes from them churns up the contents of the stomach mechanically.

'The effect of wines on *pancreatic digestion* is akin to their action in the mouth, and may be entirely explained by their acid qualities' (Chittenden).

It must be remembered that the above remarks apply only to the effects of wines upon the *chemical* processes of digestion. As in the case of alcohol, it by no means follows that the net result of taking wine with meals is unfavourable; for, by the increase of appetite and gastric secretion which they induce, they may, in moderate quantity at least, not only neutralize any inhibition of the merely chemical processes which they exert, but actually render digestion quicker and easier than it otherwise would be. This, indeed, is one of the most useful actions of wines both in health and disease.

General Action of Wines in Health.—'The conventional value of wine is determined less by its principal ingredients than by the prominence of the specific character termed *bouquet* and the absence of certain faults. Dietetically, most wines are of equal value provided they are the products of a favourable season, pure and free from the faults produced by fungi' (Thudichum).

'I have purposely made no attempt to answer the question so frequently and so uselessly put, "Why is one kind of wine better than another?" Every constituent helps to promote excellence: alcoholic content, bouquet, and every non-volatile ingredient. One wine is liked on account of its aroma, another on account of its strength, a third simply because of its flavour' (Mulder).

These two quotations contain the gist of most that can be said as to the action of different wines on the human body. Nevertheless, they do not embrace quite the whole truth. We may admit that, for the purposes of dietetics, most sound wines are equally good as long as their alcoholic strength is the same, and that the æsthetic qualities determine their market much more than their hygienic value; but it must be remembered that a wine may contain ingredients which elude chemical analysis, but which are yet not without influence upon health, for, as has been truly said, 'the human brain and the human stomach are the only analysts which never make mistakes.'

The subject is further complicated by the fact that different constitutions react very differently to the same wine, a fact which must be within the experience of everyone. To some extent this may be explained by difference of habits, the sedentary man, for example, requiring to be much more sparing in his use of certain wines than his fellow of more active pursuits; but this does not account for all the facts, and much must be put down to what, for want of a better name, one can merely describe as idiosyncrasy.

In endeavouring to get further light on the subject, we shall do best to consider the effects of the principal constituents of wines on the body individually, and afterwards attempt to deduce from the results of that study some general rules for our guidance in recommending wines in health and disease.

Alcohol.—As a general rule, the stimulating action of any wine depends chiefly upon the amount of alcohol which it contains. Now, the natural wines only contain about half as much alcohol as the strong or fortified wines, so that two bottles of good claret or hock are about equal, as far as alcohol is concerned, to one bottle of port or sherry.

Roughly speaking, then, the stimulating action of a fortified wine may be regarded as twice as great as that of a natural wine. This, however, is not necessarily quite true in any given case. Wines cannot be regarded as mere mixtures of alcohol and water in different proportions. For one thing, the mere fact of dilution is of importance. The more dilute the alcohol is, the more slowly it will be absorbed, and the less the chance of a large quantity of it reaching the tissues at one moment. The ethers and other volatile constituents, too, have a certain modifying influence upon some of the actions of alcohol, and a wine which is rich in these elements may be expected to have a different effect from another which is devoid of them, even although the two are of equal alcoholic potency. Notwithstanding this, and when all due weight has been given to such modifying factors, one is pretty safe in concluding that it is only the weaker, *i.e.*, natural, wines which are adapted for habitual use as accessories of the diet. We have further learnt that from 1 to 2 fluid ounces of alcohol is about the amount which can be safely taken in one day. Now, 2 fluid ounces of alcohol are contained in one bottle of good claret or hock, and therefore we may conclude that half a bottle daily of such wines is a safe allowance for a sedentary individual, and a whole bottle is enough for a man of more active life. The fortified wines, on the other hand, should be

reserved for special occasions, or should only be used as medicines under medical advice.

Acids.—We have seen that acids are an indispensable ingredient of all wines, and that they are chiefly present in the form of bitartrate of potash, but that some wines contain a certain proportion of volatile acids, such as acetic, in addition. To the healthy man the amount of acid present in any reasonably sound wine may be regarded as harmless, but it is generally believed that wines with a high degree of acidity may be injurious to some constitutions, and especially to the gouty and the rheumatic. It is doubtful whether this proposition can be maintained in such an absolute form. One must remember that the organic acids and their salts contained in wine are converted in the body into alkaline compounds, and are excreted as such. Certainly bitartrate of potash increases very appreciably the alkalinity of the urine. It is difficult to see, therefore, how its presence in wine can be other than beneficial, as far as gravel, at least, is concerned. As a matter of fact, Liebig long ago pointed out that the free use of hock (a rather acid wine) tended to prevent the precipitation of uric acid in the urine. The same is true of cider. Those who drink largely of it are not troubled with gravel; indeed, they are stated to enjoy a special immunity from that disease, for it not only renders the urine less acid, but increases its volume, so much so, indeed, that in Normandy the young and inexperienced practitioner is constantly diagnosing an imaginary diabetes.

It may be objected that, although this may all be true as regards the deposit of uric acid in the urinary passages, yet the acidity of wines may render them harmful in the tissues before the oxidation of their organic acids into alkaline forms has had time to take place. Even this, however, is very far from being proved, and Luff has shown[1] that, as a matter of fact, the most acid wines are *not* those which are most generally credited with being producers of gout. The supposed connection, indeed, between variations in the alkalinity of the blood and the occurrence of gout has probably been exaggerated, and demands much further investigation.

The action of the **tannin** in wine must be sharply distinguished from that of its other organic acids. A ***rough*** or ***astringent*** and an acid wine are by no means the same thing, though there can be little doubt that the former is often mistaken for the latter. The red wines, as a class, are richer in tannin than the white, and port, especially when young, is one of the richest of all. Burgundy, on

[1] 'Gout: its Pathology and Treatment,' Cassell and Co., 1898

the other hand, does not seem to contain a large amount of this constituent. Owing to this property, red wines may be useful in diarrhœa and harmful to the constipated, but it is a mistake to suppose that the mere presence of roughness or astringency (*i.e.*, of tannin) in a wine confers upon it any special strengthening qualities.

Sugar.—There can be little doubt that the craze at present is for *dry*, *i.e.*, sugar-free, wines. It is interesting to inquire whether this can be justified. We have seen that the total amount of sugar which can be consumed daily in the form of wine, no matter how sweet, is so small that it can be neglected from a merely *nutritive* point of view. The further question therefore arises, Is the comparatively small quantity of sugar, which even the so-called 'sweet' wines contain, in any way injurious to health? Here, again, it is the gouty who are believed to be subject to special risks. There is no more reason, however, to believe that the sugar of wines, *per se*, is any more harmful to such persons than their acids are. It is interesting to note in this connection that it is the fortified wines which, as a class, are the sweet wines, and the natural wines which (with a few exceptions) are *dry*, and the suspicion naturally arises that it is the greater amount of alcohol in the sweet wines which renders them dangerous to the gouty (even granting that such danger has been proved to exist), rather than the sugar which they also contain.

It is probable, indeed, that it is the combined presence of both sugar and acid in a wine which renders it harmful to the class of whom we are speaking rather than either of these ingredients alone. There is certainly some reason to believe that such a wine is more apt to excite an 'acid' dyspepsia in gouty subjects than dry wines are. This may perhaps be due to the rapid absorption of sugar from the stomach in the presence of alcohol, and its replacement by a large quantity of highly acid gastric juice. It may perhaps be the case, too, that fermentation is apt to be restarted in a fortified wine once its alcohol is diluted in the stomach, and that this may give rise to the production of acid substances. Be the explanation what it may, the gouty man does well to avoid the fortified wines unless very dry, for such a dyspepsia is prone to be the signal for an attack of gout.[1]

[1] The *Lancet* (February 25, 1899) gives the following list of practically sugar-free liquors which may be recommended to diabetics and the gouty:

	Percent. of Sugar.
Champagne 'Sans Sucre' (Hertz and Collingwood) ..	0·2
Californian Burgundy (Haig, Smith and Co., Manchester)	0·15
" Claret " " "	0·14

The action of the *extractives* of wine on the body is obscure. It has been supposed by some that their influence is akin to that of the extractives of meat, and they are believed to help in the making of blood. It may be worth while remembering that extractives are most abundant in old wines and those of good vintage.

The *volatile constituents* of wine include the ethers and essential oils, the latter, along with certain highly-oxidized aldehydes, being probably chiefly responsible for the quality known as 'bouquet.' The action of these upon the body in health is probably slight, though they may exercise a modifying influence upon the intoxicating tendency of the alcohol along with which they occur. In disease, on the other hand, the ethers, and especially their volatile members, seem to have often a most valuable stimulating influence on the exhausted brain and heart.

In attempting to summarize the points which have been raised in this discussion as to the use of wines in health, I cannot do better than quote the conclusions of Anstie:[1]

1. Wines for daily use by healthy adults should not on the average contain more than 10 per cent. absolute alcohol (by weight); 8 or 9 per cent. is better.

2. If wine be used as the daily drink, it is best, as far as may be, to use only one kind at a time and no other form of alcoholic liquid.

3. Sound natural wines are to be obtained at the best economic advantage from the Bordeaux district; the red wines are to be preferred.

4. Rhine wines (white) are equally excellent, but more expensive.

5. Hungarian wines are also in many instances excellent, but they are unequal in quality owing to defects of manufacture.

	Percent. of Sugar.
Australian Burgundy (Burgoyne)	0·28
South Australian wines (Orion Brand, E. Burney Young, 35, Walbrook Street, E.C.):	
Cabernet	0·14
Burgundy	0·16
Reisling	0·20
Dry Imperial Champagne (Moët and Chandon)	0·65
Cider (Gaymer and Son)	0·7 to 2·12
Harvey's Pale Ale	None.
Back and Co.'s Anti-diabetic Non-acid Whisky	,,
Dewar and Sons ,, ,, ,,	,,
Vibrona Champagne	0·13
,, Sherry	0·20
Vitali's Italian wines	0·11 to 0·17

[1] 'On the Uses of Wines in Health and Disease' (Macmillan and Co., 1877), p. 39.

6. Greek wines labour under the same defects.

7. The fortified wines, as a class, develop no proper vinous qualities till they have been for some years in bottle. Sherry, however, is greatly superior to the other wines of this class in the rapidity with which it develops the volatile ethers.

8. Fortified wines in small quantities, especially sherry, for the reason just named, are the appropriate stimuli of certain kinds of infantile and youthful debility, and of the enfeebled nervous system of old persons.

9. Half a bottle of a natural wine a day for a sedentary and a bottle a day for a vigorous and actively-employed adult affords a reasonable and prudent allowance of alcohol, and this quantity of wine, either alone or with water, will be enough to satisfy the needs of moderate persons for a beverage at lunch and dinner, the only two meals at which alcohol should, as a rule, be taken.

The use of wines in disease will be considered in subsequent chapters.

CHAPTER XXII

THE COOKING OF FOODS[1]

THE object of cooking is twofold:

1. *Æsthetic*—to improve the appearance of the food and to develop in it new flavours.

2. *Hygienic*—to partially sterilize the food and to enable it to keep longer.[2]

It is an error to suppose that cooking increases the digestibility of food. That is only true of vegetable foods. The digestibility of animal foods is diminished rather than increased by cooking. This is true at least of the *chemical* processes of digestion, though the increased attractiveness of well-cooked food may render it indirectly more capable of digestion by calling forth a more profuse flow of psychical gastric juice (see p. 396).

The application of heat in some form or another being the essential part of all ordinary processes of cooking, it is important to have clear ideas as to the **effect of heat upon the different chemical constituents of the food.**

The effect of heat on the *proteids* of the food is to coagulate them. It would be a complete mistake, however, to suppose that a boiling temperature is essential for the bringing about of this change. As a matter of fact, all proteids, both animal and vegetable, are coagulated if their temperature is raised to 170° F. We shall

[1] The reader may also consult on this subject 'The Chemistry of Cookery,' by W. Matthieu Williams (London, Chatto and Windus, 1892); Thudichum's 'Spirit of Cookery' (London, Baillière, Tindall and Cox, 1895); and Sir Henry Thompson's 'Food and Feeding,' ninth edition (London, Frederick Warne and Co.), chapters v. and vi.

[2] *No animal* parasite found in meat is capable of withstanding a temperature of 70° C. All ordinary forms of cooking will therefore render meat free from this source of infection. On the other hand, many pathogenic bacteria, such as those of splenic fever, malignant œdema, septicæmia, and chicken cholera, if present in the interior of meat, might quite easily escape being killed by the temperatures usually reached in ordinary methods of cooking.

subsequently see that ignorance of this fact is a fertile source of errors in cooking. If the temperature be raised much above this point, the proteid tends to shrink and harden, and the digestibility of the food in which it is contained is proportionately lessened.

Of the *carbohydrates* of the food, starch is most affected by heat. Dry heat converts starch into a soluble form, and ultimately into dextrin. This change occurs to a limited extent in the crust of bread, and also in the making of toast. Moist heat causes the starch grains to swell, and ultimately to rupture their cellulose envelopes, and the starch is then said to be *gelatinized*. That this change also takes place considerably below the boiling-point of water is shown by the following table of the gelatinization-points of different kinds of starch :[1]

Oat	185° F.
Barley	176° F.
Rye	176° F.
Wheat	176° F.
Rice	176° F.
Maize	167° F.
Potato	149° F.

Here again one sees that in the case of some starchy foods, at any rate, the change which it is the object of cooking to effect can be brought about at a comparatively low temperature.

The effects of heat upon *sugar* have already been described, and it need only be mentioned here that the partial conversion of sugar into caramel is one of the means by which flavour is developed in food by cooking.

The *fats* of food do not appear to be so much affected by heat as the proteids and carbohydrates. At high temperatures, however, as when one or other of the dry methods of cooking is employed, some at least of the fat may perhaps undergo a partial decomposition, with the liberation of free fatty acid.[2] This may explain why it is that hot fat is so much more apt to prove irritating to the stomach than cold fat, for it is not improbable than the fatty acid may reunite with glycerine to form neutral fat on cooling. Fat which has been heated and allowed to cool again is often found to have become more granular than it was before. This change is probably due to the driving off of water, and it tends to render the fat more brittle, and consequently more digestible than it was before. The change is well exhibited in the case of dripping, and also in fried bacon.

With these preliminary considerations we may proceed to the

[1] From Sykes' 'Principles and Practice of Brewing,' p. 70.
[2] See also Matthieu Williams' 'Chemistry of Cookery,' p. 158.

study of the effects of cooking upon animal and vegetable foods respectively.

1. Cooking of Meat.

The ideal to be aimed at in cooking meat is to decompose its red colouring matter (hæmoglobin), so as to remove its raw appearance, and to do this without overcoagulating the solid proteids of the meat or removing from it its flavouring ingredients (extractives).

We may glance very briefly at the means by which this ideal is to be attained in the ordinary methods of cooking.

1. **Boiling.**—It is unfortunate that the term 'boiling' should be applied at all to any method of cooking meat, for it implies that the subjection of the meat to the temperature of boiling water (212° F.) is an essential of the process. But this, for the reasons indicated above, is a mistake. The red colouring matter of the meat is decomposed and rendered brown at a temperature considerably below that of boiling water, and by going up to the boiling-point one runs the risk of hardening the meat by overcoagulation of its proteids.

That the boiling-point is not essential for the complete coagulation of the proteids can be most easily proved in the case of an egg. If two eggs are taken, and one kept in water at a temperature of 175° F. for ten or fifteen minutes, and the other for an equal length of time in boiling water, it will be found at the end of the experiment that the contents of both are solid throughout, but that in the case of the former they consist of a tender jelly, whereas in the boiled egg they are dense and almost leathery. Several so-called egg-boilers, indeed, have now been introduced which go upon the correct principle of cooking the egg at a temperature considerably below the boiling-point of water.

Now, what is true of an egg holds good also for meat, and accordingly the first principle to be observed in the 'boiling' of meat is to see that the temperature of the water does not rise much above that which is required for the coagulation of proteids. It is only by giving heed to this that one can achieve the first result desired—the abolition of the raw colour of the meat with avoidance of overhardening.

The second object to be aimed at, that of retaining all the flavouring constituents of the meat, also demands some care. The flavour of meat is due to its extractives and salts, and both of these are readily dissolved by water. If the water in which the meat has been cooked is to be consumed in the form of soup, the partial

removal of some of these flavouring ingredients is not of much importance; but if the meat alone is to be eaten, precautions must be taken to prevent their being dissolved out.

One way of doing this is to use as *small a quantity* of water as possible; for the larger the proportion of water to meat, the greater will be the amount of soluble substances removed. The quantity of water, therefore, should be just sufficient to cover the meat, and no more.

The other way of obviating removal of soluble substances is to *seal up* the piece of meat. This is best achieved by plunging it into *boiling* water, and leaving it there for a few minutes. This causes a rapid and complete coagulation of the proteid in the fibres of the meat, which forms an almost impermeable layer on the surface, and shuts in the soluble constituents. When this has been done, the temperature of the water should be lowered, and the process of cooking continued slowly.

2. In the process of **roasting** the heat is conveyed to the meat by direct radiation, instead of through the medium of water. Here, again, high temperatures should be avoided, except at the outset, when it is necessary to effect a sealing of the surface, for the same reason as in boiling. If the piece of meat is thin, the high temperature to which it is first exposed not only seals the surface, but also coagulates the proteid throughout the whole thickness, so that the meat is practically cooked at once. This happens, for instance, when a chop is cooked on the grill, and the completeness of the sealing is shown by the fact that the water vapour produced from the fluids in the meat is unable to escape, and by its expansion causes the chop to assume that puffy form which is a sign of skilful cookery. In the case of a large joint the heat does not penetrate with sufficient rapidity to admit of instantaneous cooking, and in that case a long exposure to a lower temperature is required after the surface has once been sealed. Desiccation of the meat during this period is prevented by continuous basting, which forms a sort of impenetrable varnish of fat over the surface. Roasting, if properly performed, not only prevents the escape of the natural flavourers of the meat, but develops in it substances which are themselves of a sapid nature. This is due to a change which it brings about in the extractives on the surface, analogous to the alteration which sugar undergoes in its conversion into caramel. This results in the production of the dark-brown, sticky substance on the surface of a roast joint which is familiar to everyone, and which is sometimes termed *osmazone*. It is one of the most sapid substances known.

3. **Baking** acts in precisely the same way as roasting, the heat in that case being applied all round the meat at once, instead of only to one side at a time. The production of osmazone by this process is, however, rather limited.

4. **Stewing** is in many respects the ideal method of cooking meat. If properly performed, it coagulates without overhardening the proteids, while, owing to the fact that the juice is eaten along with the meat, none of the flavouring ingredients are lost. At the same time, the prolonged action of heat and moisture converts most of the connective tissue into gelatin, so that the fibres readily fall apart and the meat becomes very tender. Here, again, the secret of success consists in avoiding too high temperatures. It is not sufficient to place the pan by the side of the fire, and allow it to 'simmer' instead of 'boil.' The use of a thermometer will show that the temperature of 'simmering' and 'boiling' water is really the same, *i.e.*, 212° F., the only difference being that in the former case the heat is reaching the water more rapidly and more of it is wasted. In proper stewing the temperature should not be allowed to rise above 180° F.

2. Cooking of Fish.

The flavouring ingredients of fish are even more easily dissolved out by water than those of meat; and as fish has less flavour to start with, any loss is the more carefully to be avoided. For this reason boiling, unless very carefully performed on the lines above laid down, is not a suitable method of cooking fish. The experiments of Sir Henry Thompson[1] show that even when carefully performed it is apt to result in a loss of at least 5 per cent. of solid matter. For this reason cooking by means of water-vapour (steaming) is preferable, just as it is in the case of some vegetables.

Baking and roasting are also appropriate means of cooking fish, if carried out with the same precautions as in the case of meat.[2]

Frying is a method of cooking specially applicable to some forms of fish, and demands a special word of description, especially as the process is so often misunderstood.

The essence of frying consists in the sudden exposure of the object to be cooked to a very high temperature. This has the effect of producing an instantaneous coagulation of the proteids on the surface, along with a slight degree of charring. Any escape of

[1] 'Food and Feeding,' p. 196.

[2] For details of the method of roasting fish see Sir Henry Thompson, *loc. cit.*, p. 193.

soluble substances is thus prevented, while the surrounding temperature is so high that the fish or other substance is practically cooked throughout its whole thickness almost instantaneously.

In order to attain this very high temperature, some form of fat must be used as a medium. Olive-oil or good cottonseed-oil are best. The oil should be heated in a deep pan almost to boiling-point (the exact temperature is about 350° to 390° F.); and when this temperature has been reached the object to be fried should be suddenly plunged into the pan, and left for two or three minutes. The sputtering which ensues is due to the sudden conversion of the moisture on the surface of the object into steam. When this has ceased the cooking will be complete, and the object should be lifted out and the excess of oil allowed to drain off.

It will be observed that this process differs entirely from the so-called 'frying' usually practised in this country, in which the fat employed is regarded merely as a means of preventing the object from adhering to the surface of the shallow pan, in which a sort of roasting is really accomplished.

3. Cooking of Vegetable Foods.

In the cooking of vegetable foods the objects to be achieved are different from those which one seeks to accomplish in the case of animal foods. Cellulose and raw starch are almost incapable of digestion by man, and hence the softening and rupture of the cellulose framework of a vegetable food and the gelatinization of its starch grains are the chief ends which it is the purpose of cooking to bring about.

Cellulose can be softened, and, indeed, partly converted into sugar, by the action of acids, aided by heat. This is Nature's method of dealing with it. In its unripe state a pear or other fruit is hard and 'woody' from the presence of a cellulose framework. In process of ripening the acids in the fruit, aided by the heat of the sun, effect a softening of this framework, with partial or complete solution of the cellulose fibres, the product being the sweet and soft ripe fruit.

This method is sometimes unconsciously imitated by man. The process of preparing *ensilage* is an example of it. Here, under the influence of fermentative bacteria, acids are produced in grass which, by the aid of moisture and heat, act upon the cellulose, and effect a partial conversion of it into sugar. In Germany a very similar process is employed in the conversion of cabbages into *sauer-kraut*.

The preparation known as *sowans* is an example of the operation of a similar agency on the cellulose of oatmeal. Ordinary porridge, also, when allowed to stand for some time, becomes a soil for the growth of acid-forming bacteria, and the products of the growth of these bring about some degree of softening of the cellulose in the particles of oatmeal. For this reason stale porridge is often found to be more digestible than the perfectly fresh form of that food.

Another way of overcoming the cellulose obstacle, which may in a sense be regarded as a process of cooking, is by *milling* or *grinding*. This breaks up the cellulose framework, and allows the digestive juices to penetrate into the nutritive ingredients which it encloses.

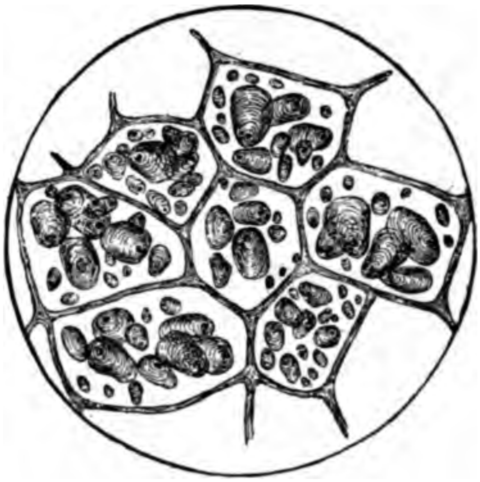

FIG 29.—CELLS OF A RAW POTATO, WITH UNRUPTURED STARCH GRAINS AND CELLULOSE FRAMEWORK.

More commonly, however, one finds the same object accomplished by the combined action of heat and moisture. When exposed to moist heat starch grains, as we have seen, swell up, their envelopes rupture, and they run together to form a paste or starch jelly. As this jelly expands it presses upon and ultimately ruptures the framework of cellulose in which the grains are enclosed, and in this way the two chief objects aimed at are achieved. The degree to which this occurs in different cases is very well shown in the accompanying diagrams (Figs. 29, 30 and 31), which illustrate the action of moisture and heat upon the structure of a piece of potato.

It will be evident from these considerations that cooking is of immense importance in facilitating the digestion of vegetable foods,

and the larger the proportion of cellulose present, the more essential does thorough cooking become.

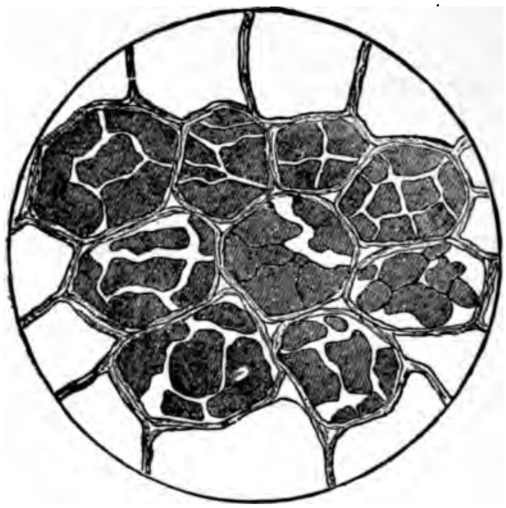

FIG. 30.—CELLS OF A PARTIALLY COOKED POTATO, THE STARCH GRAINS RUPTURED.

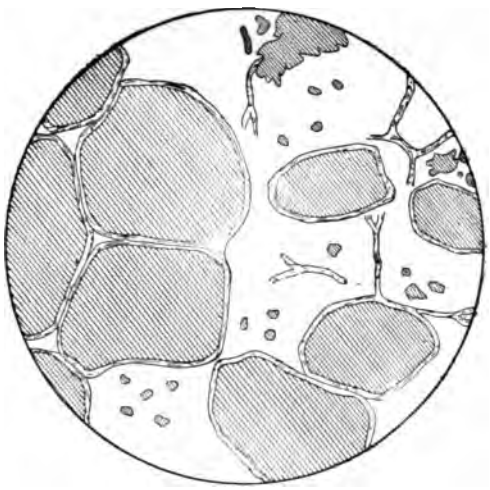

FIG. 31.—CELLS OF A THOROUGHLY BOILED POTATO; CELLULOSE FRAMEWORK BROKEN DOWN.

On the *proteids* of vegetables heat has an effect precisely similar to that which it exerts on the same constituent of animal foods; that

is to say, they become coagulated. Now, the coagulation of proteids is accompanied by shrinkage rather than by swelling, and for this reason, if the cellulose framework encloses proteid only, it does not become ruptured; and one can therefore readily understand that if a vegetable food contained proteid only its digestibility would be affected by cooking in a precisely similar way to that of animal food; in other words, it would be rendered less rather than more digestible by the process. As a matter of fact, however, there is hardly any vegetable food which does not contain much starch as well as proteid, and hence it is that the general rule holds good that cooking increases the digestibility of vegetable foods.

Losses in Cooking.

No matter how carefully cooking is performed, a certain amount of loss of the soluble constituents of the food during the process is almost inevitable. In the case of meat, it has been found by Johnston that—

	In Boiling.	*In Baking.*	*In Roasting.*
4 lb. of beef lose in weight ..	1 lb.	1 lb. 3 oz.	1 lb. 5 oz.
,, mutton lose in weight	14 oz.	1 lb. 4 oz.	1 lb. 6 oz.

By far the larger part of this loss, however, is due to water. This is shown by the following analyses given by König:

COMPARATIVE COMPOSITION OF MEATS BEFORE AND AFTER COOKING.

	Water.	*Nitrogenous Matter.*	*Fat.*	*Extractive Matter.*	*Salts.*
Beef:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Before cooking (raw) ..	70·88	22·51	4·52	·86	1·23
Same after boiling ..	56·82	34·13	7·50	·40	1·15
Same after broiling (as beefsteak)	55·39	34·23	8·21	·72	1·45
Veal cutlets:					
Before roasting (raw) ..	71·55	20·24	6·38	·68	1·15
Same after roasting ..	57·59	29·00	11·95	·03	1·43

The actual loss of soluble matter is more clearly brought out when these figures are recalculated on the basis of dry substance:[1]

COMPARATIVE COMPOSITION OF WATER-FREE SUBSTANCE OF MEATS BEFORE AND AFTER COOKING.

	Nitrogen.	*Nitrogenous Matter.*	*Fat.*	*Extractive Matter.*	*Salts.*
Beef:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Before cooking	12·37	77·31	15·47	2·98	4·24
After boiling	12·65	79·06	17·38	·90	2·66
After roasting	12·27	76·73	18·41	1·59	3·27
Veal cutlets:					
Before cooking	11·39	71·17	22·45	2·32	4·06
After roasting	10·93	68·36	28·18	·09	3·37

[1] Bulletin 21, United States Department of Agriculture, p. 87.

It will be observed that the loss is entirely confined to the extractive matter and salts.

As far as their soluble constituents are concerned, vegetable foods behave similarly, the loss of salts especially being often very considerable. This point, however, has been fully dealt with when the composition of vegetable foods was described.[1]

As regards water, the behaviour of the two classes of foods on cooking is entirely different, for vegetable foods tend to become richer in water when cooked, instead of losing it. The contrast between the two in this respect is very well shown in the following figures given by Forster:

COMPARISON OF THE EFFECTS OF COOKING ON THE PROPORTION OF WATER IN ANIMAL AND VEGETABLE FOODS.

	Raw.	*Cooked.*	
Beef ..	.. 75 per cent.	Boiled ..	.. 55 to 59 per cent.
		Roast ..	.. 56 to 63 ,,
Veal ..	.. 78 ,,	Roast ..	.. 60 to 64 ,,
Flour	.. 12 to 14 per cent.	Bread ..	.. 36 to 40 ,,
		,, chewed	70 per cent.
Peas	.. 14 per cent.	Peas brose ..	68 to 78 per cent.
		Pea soup ..	90 per cent.
Potatoes	.. 75 ,,	Potato purée ..	78 ,,
		,, soup ..	91 ,,
Cabbage	.. 87 ,,	Cabbage ..	85 to 90 per cent.

One may, therefore, lay it down as a general proposition that animal foods become less watery as the result of cooking, while vegetable foods, on the contrary, become more watery.

This is another explanation of the different effect which cooking exerts on the digestibility of the two classes of foods. The concentration which meat undergoes when cooked is unfavourable to digestion, while the dilution of the vegetable foods after cooking makes less demand on the digestive juices. This, too, is one reason why meat which has been cooked more than once is rather difficult of digestion. Not only are its proteids apt to be overcoagulated, but the relative proportion of fat is increased at the same time, and both of these facts militate against rapid and easy digestion.

On the other hand, the increase of bulk which vegetable foods undergo as the consequence of taking up water in the course of cooking is apt, for reasons already explained, to throw a strain on the *mechanical*, as opposed to the purely chemical, functions of the digestive organs. The bearings of this fact upon the practice of vegetarianism have been discussed at length in an earlier chapter.

[1] See also United States Department of Agriculture, Bulletin 43, 'Losses in boiling Vegetables,' etc.

SLOW COOKING.

Food being a bad conductor, heat only penetrates into it very slowly. Wolffhügel and Hüppe,[1] for instance, found that the temperature of the interior of a piece of meat weighing 9 pounds after four hours' boiling was only 88° C., or 12° below the boiling-point of water. The interior temperature of a roast varied from 70 to 95° C., according to size. Similar observations have been made by Sir Henry Thompson.[2] He found that the temperature close to the bone of a leg of mutton which had been boiled for some hours was never above 186° or 187° F.

Hence it is that, if heat be applied to a piece of meat too rapidly, one simply wastes fuel and runs the risk of overcooking the outer layers. It is far better to allow a moderate amount of heat to act on the meat for several hours, and the longer the time allowed, the lower will be the temperature required, always assuming that it is kept above the coagulation-point of proteids. Various special forms of apparatus have been invented with the view of economizing fuel, and allowing of the prolonged action of a moderate degree of heat, some of which are certainly not as well known as they deserve to be.

The simplest of these are constructed on the principle of an ordinary water-bath, and consist of a double pan, the outer being filled with water which is kept at, or near to, the boiling-point, while the article to be cooked is placed in the inner vessel. The heat only penetrates slowly to the latter, and never reaches the boiling-point, while any risk of burning is also prevented. The French *bain-marie* is constructed on this plan. *Warren's Cooking-pot* and *Bailey's Cookers*[3] are also good examples of the application of the principle.

The *Duplex Boilerette*[4] is a modification of the *bain-marie*, in which the steam from the outer pan is prevented from escaping and reaches a high temperature, so that the food in the inner vessel can be actually boiled.

Somewhat different from these is the *Norwegian Self-acting Cooking Apparatus*.[5] This consists of an outer cylindrical vessel lined with non-conducting material, and an inner metal cylinder in which the object to be cooked is placed. If, for example, it is desired to boil a fowl, we place the latter in a saucepan of boiling water, boil it over

[1] Quoted in Bulletin 21, United States Department of Agriculture.
[2] 'Food and Feeding,' p. 96.
[3] Bailey's Patent Cookers Company, 10, Bromley Road, Beckenham, Kent.
[4] Manufactured by R. W. Welbank, North Newington, Banbury.
[5] Supplied by Silver and Co., Sun Court, Cornhill, E.C.

the fire for five or ten minutes in order to 'seal up' the surface, then remove the pan from the fire and place it in the inner cylinder. The outer lid is then closed, and, the escape of heat being thus entirely prevented, cooking is allowed to go on slowly for several hours. On opening the apparatus after the lapse of twelve or eighteen hours, the fowl will be found steaming hot, and, though thoroughly cooked, quite tender throughout. The apparatus acts on the principle of entirely preventing any loss of heat, and just as it prevents any heat getting out, so it can with equal efficiency prevent any from getting in. It may, therefore, be used as a refrigerator, for keeping ices, etc., unmelted, quite as well as a cooker. The apparatus saves a great deal of time, trouble, and fuel, and is very useful to travellers and campers-out, or in any circumstances in which one wants hot food constantly ready.

A little reflection will show that, in the use of an ordinary oven, a great waste of fuel is inevitable, for the metal of which the oven is constructed is an admirable conductor, and allows heat to escape as fast as it gets in. In order to prevent this and the waste of fuel which results from it, all that is necessary is to have the oven covered with some non-conducting material. The heat supplied by the fuel will then be unable to escape from the oven, and will all be utilized to cook the food, instead of being to a large extent dissipated into the surrounding atmosphere.

An oven constructed on this plan has been devised by Canon Moore Ede for use in the preparation of penny dinners. The apparatus and its advantages are thus described by its inventor :[1]

'It consists of a box 3 feet high, 2 feet wide, 1 foot 9 inches deep, with an outer case of sheet iron. The sides and lid are lined with 2½ inches of felt, and inside this, again, is a further lining of tin. Underneath this box, which will hold 30 gallons, are placed two of Fletcher's Atmospheric Gas Burners. The felt being a non-conductor, nearly all the heat from the gas is utilized, and a comparatively small expenditure of gas suffices to raise the temperature of the contents of the box to boiling-point, or to the heat required for the food which is being cooked.[2]

'When once the desired temperature is obtained, one of the burners can be turned off and the other lowered, when, owing to the prevention of radiation by the felt, it will be found that a merely nominal expenditure of gas will enable the temperature to be main-

[1] 'Cheap Food and Cheap Cooking' (London: Walter Scott), 1884.

[2] Since the above was written, sundry alterations and improvements have been made which considerably increase the economy and efficiency of the apparatus.

tained for hours, and even when the gas is totally extinguished many hours will elapse before food cooked will become cool.

'But except in the case of puddings which require rapid boiling, the cooking is done in an inner pan, which is placed inside the box, and which contains rather more than 20 gallons. The apparatus may be best described as a huge Warren's pot, with the additional advantage that the whole of the inner pan is surrounded by warm water.

'The space between the inner pan and the side of the box is filled with water, which is kept at the temperature desired by means of the gas burners.

'The chief advantages of this apparatus are as follows:

'Economy in first cost of the apparatus, which can be procured from Messrs. Emley of Newcastle.

'There is little, if any, smell of cooking.

'The apparatus can be placed in any room, and no arrangement of flues is required. The iron pipe which takes away the fumes of the gas can be carried into the chimney, if there is one in the room, or, if there is no chimney, through a small aperture in the window.

'As the felt retains the heat, the exterior of the box remains cool, and the temperature of the room is scarcely affected; indeed, so slight is the smell of cooking, so little the heat radiated, that the apparatus might almost be placed in the schoolroom itself.

'Owing to the inner tin and the box itself being firmly closed, no evaporation takes place, and all the nutriment and flavour of the food is preserved.

'Surprising though it may sound, there is a gain of nearly 30 per cent. in quantity in the case of meat cooked in this way; in preparing soup less of the nutrition of the meat is lost, and vegetables are more palatable as well as more nutritious when cooked in the manner described.

'Most food is improved by being cooked very slowly; this can be easily done by this apparatus, and also it can be so adjusted that each kind of food can be cooked at the temperature which most effectively brings out its nutritious qualities; this for meat is at about 170° F., for pulse about 200°.

'The expenditure for fuel is very slight; gas costing seven-tenths of a penny will in this apparatus raise 5 gallons of water to boiling-point, and less than 3d. is sufficient to boil 30 gallons. Once boiled, the temperature can be retained at a nominal expenditure of gas.

'Another advantage is that no food can be burned, and no care is required to prevent that very common catastrophe. The food once

placed in the inner tin in proper proportions, and the space between the inner and outer case filled with water, the lid is closed and the gas turned on till the required temperature is reached; it is then lowered, and the dinner is left to take care of itself. As it is often convenient to prepare the dinner the previous afternoon, it is not unfrequently left cooking at a low temperature the whole night. All the labour entailed by keeping up a coal fire is avoided, and also the constant attention usually necessary to prevent burning.

'The only defect of the apparatus is that it is not capable of baking, but in the case of school dinners I think this will be found of little consequence.'

The *Aladdin Oven*, invented by Dr. Edward Atkinson, is on the same principle. 'It is a simple iron box, closed in front by a door, and having an opening in the top that communicates with a tube to let off any superfluous steam. This box is surrounded by another, whose top and sides are made of non-conducting material for the purpose of holding the heat. A standard, on which this box is set, and a lamp underneath complete the apparatus.'[1]

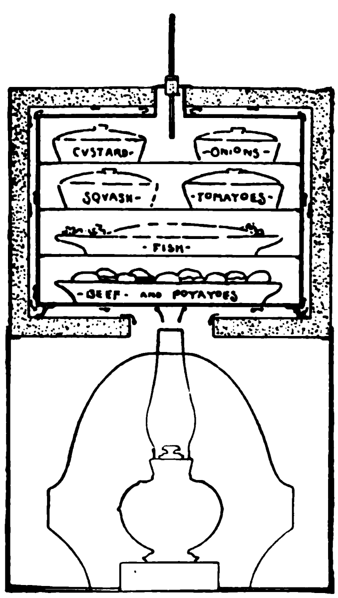

FIG. 32.—THE ALADDIN OVEN. (AFTER ATKINSON.)

A clearer idea of the structure of the oven will be obtained from the accompanying diagram, borrowed from Dr. Atkinson's interesting book (Fig. 32).

The oven can be heated either by a kerosene lamp or by a small gas burner, and it will raise the temperature of 40 pounds of meat and 15 quarts of water to 180° F. in the space of seven hours, and if the lamp is then removed the temperature undergoes no appreciable diminution for fully four hours.

Dr. Atkinson calculates that in an ordinary oven 2 pounds of fuel must be expended for every pound of food cooked, whereas in his apparatus 2½ pounds of fuel will cook 60 pounds of food, and that the daily cost of cooking by it amounts to only ½d. per person for a

[1] Edward Atkinson, 'The Science of Nutrition and the Art of Cooking in the Aladdin Oven' (Boston, Damrell and Upham), 1896.

family of ten. The saving of trouble also is enormous, for the apparatus can be left to cook by itself overnight.

In 1889 and 1890 a number of experiments were made in America by Mrs. Ellen H. Richards and Mrs. Mary H. Abel on the best methods of cooking food. They state in their report[1] that 'for simplicity, effective use of heat, economy of fuel and development of flavour in the food cooked, combined with increase of its digestibility, the Aladdin Oven is an apparatus far exceeding in merit any other now in the market.' A friend of the writer's has used the oven for several years with the most satisfactory results, and his experience entirely bears out the favourable opinion expressed in the above report. It only remains to add that the oven can easily be constructed by any intelligent tinsmith.

It is interesting to note that the advantages of slow cooking are well known to some savage tribes, and in this respect the civilized cook has something to learn from them.

This is the method of cooking practised by the Kanakas of the Friendly Islands, as described by Mr. F. T. Bullen :[2]

'A hole is scooped in the earth, in which a fire is made (of wood), and kept burning until a fair-sized heap of glowing charcoal remains. Pebbles are then thrown in until the charcoal is covered. Whatever is to be cooked is enveloped in leaves, placed upon the pebbles, and more leaves heaped upon it. The earth is then thrown back into the cavity and well stamped down. A long time is, of course, needed for the viands to get cooked through; but so subtle is the mode that overdoing anything is almost an impossibility. A couple of days may pass from the time of 'putting down' the joint, yet when it is dug up it will be smoking hot, retaining all its juices, tender as jelly, but, withal, as full of flavour as it is possible for cooked meat to be. No matter how large the joint is or how tough the meat, this gentle suasion will render it succulent and tasty; and no form of civilized cookery can in the least compare with it.'

No better illustration of the advantages of *slow* cooking could well be found.

[1] Bulletin No. 21, United States Department of Agriculture, p. 94.

[2] 'The Cruise of the *Cachalot*' (London: Smith, Elder, and Co.), p. 273.

CHAPTER XXIII

THE DIGESTION OF FOOD IN HEALTH

The object of the present chapter is not so much to describe the merely chemical processes of digestion, which are fully dealt with in all text-books of physiology, as to consider the bearing of some physiological facts upon such matters as the selection of foods, the arrangement of meals, and other practical questions in dietetics. As it is difficult to treat the subject quite systematically, it will be more convenient to arrange the principal facts under separate headings.

Digestion in the Mouth.

The mouth stage of digestion is mainly a mechanical one, and its object essentially protective. By reducing the food to a pulp, by breaking up and softening hard particles, by neutralizing or diluting irritating constituents, such as acids, and by surrounding the whole mass with a wrapping of mucus, it is sought to guard the stomach against the effects of the ingestion of injurious substances. In the accomplishment of this object thorough chewing is of the first importance, and if the food is to be thoroughly chewed it must be eaten slowly. To 'bolt' the food in the manner—as it has been described—in which one posts letters interferes gravely with proper disintegration, and many a case of dyspepsia is kept up, if not actually produced, by imperfections of the teeth.

At the same time, it must not be forgotten that there is a chemical side to mouth digestion as well. Starch, under the action of the ptyalin in the saliva, and by processes which need not here be described, is reduced to soluble forms. The degree to which this occurs varies, partly with the form of the starch, and partly with the consistence of the food and the reaction of the medium.

Some forms of starch—*e.g.*, that of rye and maize—are much more readily acted upon by the saliva than others, such as potato starch,

while whole grains of raw starch, owing to their cellulose coating, are hardly affected at all.

Porous foods, into which the saliva can readily penetrate, are more easily attacked than dense and compact masses of food, such as new bread. Moist substances, too, offer less resistance than those which are dry. As regards this matter Pereira has pointed out an analogy in the preparation of tinctures by percolation, the substance to be extracted being much more readily acted upon if it has been subjected to a preliminary moistening. In accordance with this, it has been found that dry bread, taken alone, is digested to a much smaller extent in the mouth than if it be eaten along with water. A natural provision is made for the larger amount of ptyalin required for the digestion of dry foods, for Pawlow found, in his experiments on dogs, that such articles caused a much greater reflex flow of saliva than moist foods did. The latter, indeed, seemed hardly to provoke any flow of saliva at all. We have here a confirmation of the view that the uses of the saliva are mainly mechanical, for the object of the increased flow is apparently to moisten the dry food, even more than to digest its starch.

In describing the influence of such articles as vinegar, malt liquors, wines, etc, on salivary digestion, it was pointed out how marked was the retarding effect of the acids which these fluids contain upon the action of ptyalin, and the same was found to hold good for the tannic acid in tea. It must be noted, however, that the merely chemical effect of these beverages may be to a large extent counteracted by the more profuse flow of saliva which they often induce. All sour fluids possess this property, and the warmth of tea and the bitter ingredients of beer enable them to exert a similar effect. Wines, however, do not seem to be powerful sialogogues, though some of them, *e.g.*, sherry, excite a more abundant secretion of mucus.[1]

DIGESTION IN THE STOMACH.

Just as the chief object of digestion in the mouth is to protect the stomach, so the chief object of digestion in the stomach is to protect the intestine. Observations of the results of complete removal of the stomach in man have shown that its co-operation cannot be regarded as essential to the complete digestion and absorption of an ordinary mixed diet, provided the latter be presented to the intestine in a suitable mechanical form.[2]

[1] See Aitchison Robertson, 'The Salivary Digestion of Starch in Simple and Mixed Diets,' *Journal of Anatomy and Physiology*, xxxii. 615, 1898.

[2] Schlatter, *Lancet*, January 15, 1898.

The chief functions of the stomach, indeed, are probably these:

1. To act as a reservoir.
2. To reduce the food to a semi-fluid form.
3. To partially sterilize the food.
4. To regulate its temperature.
5. To effect a slight degree of absorption.

We shall briefly consider each of these functions separately.

1. By acting as a **reservoir**, the stomach enables us to take our food in considerable quantities at a time; *i.e.*, it renders *meals* possible. The practical convenience of this needs no demonstration, but some other points connected with the question of meals require to be raised.

And firstly it may be asked, At what intervals should meals be taken? Is it better to take several small meals, or to consume one's daily supply of food at one or two sittings? The reply undoubtedly is that several small meals are best. The 'one-meal-a-day man' is at a double disadvantage: (1) he is apt to overburden the mechanical powers of his stomach by the mere weight of food introduced into it at one time; (2) some of the constituents of food so introduced are partly wasted, owing to the assimilative powers of the tissues being unable to keep pace with the flood of nutriment which reaches them all at once. Let us consider each of these points for a moment.

(1) The capacity of the human stomach is very variable, both in different individuals and in the same individual at different periods of life. On the average it may be put down as from 1 to 2 litres,[1] and in the case of solids at about 2 pounds. If one remembers that the total amount of solid food required daily is at least 3 pounds, it is evident that if one were to take the whole of this in one meal he would be apt to overtask the powers of the stomach, or to produce a gradual dilatation of the organ. In the case of persons of feeble digestive power the limitation of the bulk of meals is of even greater importance. For them 'little and often' is the golden rule.

(2) There is evidence to show that more food is wasted when it is all taken at once than when it is spread over a considerable time. The waste chiefly affects the proteids, which are the most rapidly digested of the constituents of the food, and is partly due to defective absorption and increased opportunity for intestinal putrefaction. Ranke, for instance, found that if he ate 1,800 grammes of meat all at once the loss by the bowel amounted to 12 per cent., but if the same quantity of meat was divided into three meals the waste

[1] See Gillespie, 'The Natural History of Digestion,' p. 274, and the same author's 'Modern Gastric Methods,' p. 3, 1899.

was only 5 per cent. The loss of proteid must also be attributed in part to defective assimilation. If the tissues are so flooded with proteid that they are unable to assimilate the whole of it, the excess appears to be rapidly excreted in the form of urea instead of being stored up. This, at least, was the conclusion which Krummacher[1] drew from his experiments on dogs, in which he tested the effects of giving a certain quantity of food in one meal, and then when divided into five meals. He found that more nitrogen was excreted in the former case than in the latter. It follows from this that care must be taken not only to have enough total proteid in the diet, but to see that it is evenly spread over the day, so that the tissues may not at one time be repleted and at another be compelled to draw on their own reserves. The tissues, in fact, may be compared to a reservoir, the outflow from which is pretty constant, and to which, if it is to be kept full, the inflow should also be fairly steady. A practical example of the neglect of this principle is thus given by Clement Dukes (he is speaking of the unwise division of meals often observed at public schools):[2]

'For instance, if bread-and-butter only be provided for breakfast, say at 8 a.m., this will be digested and used up by the system long before dinner takes places at 1.30 p.m., and therefore from about 11 a.m. to 1.30 p.m. the body will be starved. Then at dinner the boy can only eat a certain amount of food, however much the caterer may supply, and thus the defect of the two hours and a half of starvation is never recovered, although growth must take place all the same.'

The **hours of meals** have varied greatly even in the same country at different periods of history, and must depend largely upon convenience and upon habits as regards work, etc. If possible, dinner, the principal meal of the day, should be taken after work is over, so that comparative repose may be enjoyed after it. As a matter of actual observation, Voit found that 50 per cent. of the day's proteid, 61 per cent. of its fat, and 32 per cent. of its carbohydrate, was taken at dinner. He infers from this that a good working dinner should contain:

Proteid	59 grammes.
Carbohydrate	160 ,,
Fat	34 ,,

2. The second function of the stomach **is to reduce the food to semi-fluid form**. This is done partly by the solvent action of the

[1] 'Wie beeinflusst die Vertheilung der Nahrung auf mehrere Mahlzeiten die Eiweisszersetzung?' *Zeit. f. Biol.*, xxxv. 481, 1897.

[2] 'School Diet,' second edition, p. 9.

gastric juice, and partly by the mechanical movements of the stomach walls. We may therefore glance for a moment at—

The Secretion of Gastric Juice.

Until quite recently it was supposed by physiologists that the secretion of gastric juice was chiefly brought about by mechanical stimulation of the mucous membrane of the stomach by the particles of food introduced into it. The elaborate and ingenious experiments of Pawlow,[1] however, have shown that this is a mistake, and that the chief factors concerned in bringing about the secretion are (1) psychical and (2) chemical, and that mechanical action plays quite a secondary part, if, indeed, it comes in at all.

The psychical factor is intimately bound up with the sensations of **appetite** and **hunger**. It is difficult to define these terms exactly, though appetite may be described as the *desire* for food, and hunger as the *need* for it.[2] Appetite is dependent partly upon hunger—as Von Noorden has it, it is to be regarded as 'the reflection of the Calorie-requirements of the tissues'—but partly also upon the state of the stomach and alimentary tract generally. Thus, an individual may complain of 'hunger' even although the stomach is full, as in those cases where a fistula exists high up in the intestine, and prevents the food from reaching the tissues;[3] or the stomach may be quite empty, and yet no complaint of hunger made, as, for example, in the case of patients who are being fed per rectum. In disease of the stomach, too, or where it is in a state of functional anæsthesia, appetite may be in abeyance, although the need for food ('tissue hunger') exists. In such a case the introduction of food into the stomach may suddenly awaken appetite. Pawlow mentions a good example of this in his own experience. He was convalescent from a trifling illness, and in spite of some days' abstention from food still suffered from complete loss of appetite. He then swallowed a glass of wine, and immediately a strong desire for food arose. This is a case in which *l'appétit vient en mangeant.*

[1] 'Die Arbeit der Verdauungsdrüsen,' Wiesbaden, 1898.

[2] This probably does not cover the whole difference between appetite and hunger. The sensation of pleasure seems inseparable from the former, that of pain from the latter. Appetite is more particularly related to the stomach, and has its seat in the brain cortex. Hunger appears to be more connected with the nutritive needs of the tissues, and possibly affects more the centres which preside over organic life. There is reason, too, to believe that the sensation of hunger is peculiarly associated with a deficiency of proteids in the blood, and can only be really allayed by a supply of them in the food. Fat, on the other hand, seems to have a special power of appeasing appetite. Advantage of this fact has been taken by Oertel in his dietary for the treatment of obesity (see p. 484).

[3] For a description of such a case see Busch, *Virchow's Archiv.*, xiv. 140, 1858.

While, then, appetite can hardly exist without some degree of hunger, the latter may be present without the accompaniment of the former. In health, however, the two seem to co-exist, and appetite is a true index of the amount of nutriment required by the tissues. It may be that some people, otherwise healthy, have habitually less appetite than corresponds to the true needs of their tissues, and this may explain some cases of malnutrition. Von Noorden[1] is of opinion that this state of things may be brought about by defective feeding in childhood, *i.e.*, by the use of food which does not make sufficient demand upon the digestive powers, and allows the stomach and intestines to grow up in a condition of functional feebleness. Hence in after-life, when compact and highly nourishing food cannot be obtained, a more bulky diet satisfies the stomach before the needs of the tissues are really supplied. For this reason, also, such persons are often poor eaters of fat, for it is difficult to take much fat without repugnance in a mainly animal form, but comparatively easy when diluted with a large bulk of vegetable food.

This discussion has led us away somewhat from our starting-point—the relation of appetite to the secretion of gastric juice. The experiments of Pawlow, already mentioned, have shown that appetite is the most powerful excitant of gastric secretion. The mere sight or smell of food and its introduction into the stomach is followed, if appetite is present, by a profuse flow of a peculiarly powerful gastric juice which may continue for as long as four hours. Hence the importance for digestion of such æsthetic aids to appetite as agreeable surroundings, a well-appointed table and good cooking, and the use before dinner of such ticklers of the palate as 'sherry and bitters' or the savoury articles usually classed on the menu as *hors d'œuvres*.

The other factor mainly concerned in producing gastric secretion is a chemical one, the active agents being the chemical constituents of the food. The remarkable fact has recently been elicited that the stimulus so exerted is not a general, but a *specific* one, each food calling forth a supply of those ingredients of the juice specially required for its own digestion. Some easily dissolved foods, for example, such as meat, produce a flow of juice large in quantity but poor in ferments; other foods, such as bread, which are more difficult of solution, cause a scanty but very concentrated juice to be secreted which is very rich in ferment; milk, again, which is one of

[1] *Berliner Klinik*, Heft 55, 1893.

the most easily digested of all foods, produces only a moderate amount of juice, and that of weak digestive power.

This capability of foods to bring about the secretion of a specific kind of gastric juice specially adapted to the requirements of their own digestion is of importance for this reason, that it enables 'digestive habits' to be very readily established. Let us suppose, for instance, that a patient has been confined for some time to an exclusively milk diet. His stomach soon acquires the habit of manufacturing a secretion specially adapted for the digestion of milk. But this, as we have seen, happens to be a secretion of small digestive power. If the diet be now changed to one, say, chiefly composed of bread, some time may elapse before the specific secretion specially suited to the digestion of bread is established, and meanwhile dyspepsia may result. This may explain why sudden changes of diet are to be avoided.

'If,' says Pawlow,[1] 'one alters the diet of an animal and goes on giving the new food, one finds that the ferments contained in the digestive juices accommodate themselves more and more every day to the altered diet. If, for example, one feeds a dog for some weeks on milk and bread only, and then changes to a purely meat diet, which contains much more proteid and almost no starch, one observes a gradual increase in the proteid ferments of the pancreatic juice. The capability of digesting proteid increases day by day, whilst, conversely, the starch-digesting power falls off. This adaptation takes place much more readily in some animals than in others. Where it does not easily occur, a sudden change of diet may produce considerable digestive disturbances.'

In the light of these facts one can understand the enormous importance of establishing good 'digestive habits' in the young. If a child is encouraged to avoid fat, for example, he may ultimately lose the power of producing the secretion specially suited to the digestion of fatty foods, and may thus, with the best intentions, be unable to eat much fat all his life afterwards, and so suffer from impaired nutrition. This is the more to be regretted as there is reason to believe that inability to digest fat renders one peculiarly liable to become the victim of tuberculous diseases.

Curiously enough, it is not *all* chemical constituents of the food which are capable of exciting a secretion of gastric juice. Egg-white, for instance, produces none, nor do the albumoses, but peptone does, and so do milk and gelatin, while the extractives of meat are amongst the most powerful excitants known. Soup makes

[1] *Op. cit.*, p. 52.

a good beginning to a meal, because it stimulates a flow of gastric juice not only by its warmth, but also by virtue of the gelatin and extractives of meat which it contains.

On the other hand, fat seems actually to restrain the secretion of gastric juice even when other foods are present as well. This is no doubt one reason why fat things are difficult to digest, and why skim milk is 'lighter' than milk rich in cream. It teaches us also that such articles as cod-liver-oil should be given some time after meals, when the gastric juice has been already poured out.

Acidity of the Gastric Contents.

The total amount of hydrochloric acid present in the stomach depends upon the quantity of gastric juice secreted. The *proportion* of acid present in the juice is very constant in the same individual. In different persons, however, it varies from about 1 to 2½ parts per 1,000 of juice. The cause of these individual differences is not quite clear, but they seem to depend to some extent upon the kind of food habitually taken, persons who live largely upon meat having usually a more acid juice than those who partake more freely of vegetables.[1] This is another example of the establishment of a 'digestive habit,' to which reference has already been made.

The total amount of acid present in the stomach rises gradually during the first three-fourths of the period occupied by the digestion of a meal, and then falls off rapidly during the remaining fourth. The fall in acidity is probably to be explained by the pouring out towards the end of digestion of a neutral or slightly alkaline juice from the pyloric end of the stomach.

Of the total amount of acid present in the gastric contents at any moment, only a small part exists in the free form; the larger part is in a state of combination. The hydrochloric acid first poured out is fixed by any bases which may be present in the food (*e.g.*, carbonates and lactates), and after these have been neutralized the proteids of the food lay hold of the rest of the acid and enter into organic combination with it, and it is only after these have been saturated that the acid is able to make its appearance in the stomach in a free form. The exact moment at which this occurs must obviously vary greatly with the amount of food in the stomach and the proportion of proteid which it contains. The larger the meal and the richer it is in proteids, the longer will the appearance of

[1] See Verhaegen, 'Physiologie et Pathologie de la Sécrétion Gastrique,' Paris, 1898, p. 9; also Gillespie, 'The Natural History of Digestion,' p. 106.

free acid in the stomach be delayed. As an illustration of this, the following observations of Penzoldt[1] may be cited:

After 7 or 8 ounces of sweetbread free acid was present in one hour.

After 7 or 8 ounces of chicken free acid was present in two hours.

After 7 or 8 ounces of beef-steak free acid was present in three hours.

After 5½ ounces of vegetable food, free acid was usually found in one or one and a half hours; but if the food was one very rich in proteid, *e.g.*, peas or lentils, its appearance was delayed for three hours or more.

The amount of *free* acid present does not usually exceed 1 part in 1,000 of the stomach contents, and its presence persists for about one and a half hours. We must now briefly consider the relations of the acidity of the stomach (1) to the gastric digestion of starch; (2) to morbid gastric sensations.

Digestion of Starch in the Stomach.

There is no doubt that ptyalin is rapidly killed by *free* hydrochloric acid, and even if 0·1 per cent. is present its action on starch ceases entirely. The effect of *combined* hydrochloric acid on the ferment, however, is by no means so certain, and the experiments of different authorities on the subject have yielded very discordant results.[2] It seems to be generally agreed, at any rate, that the presence of anything like a large amount of combined acid is highly inimical to the conversion of starch. It follows from this that the digestion of starch in the stomach is not likely to continue for more than half an hour—or at most one hour—after the taking of a meal. Obviously, the process can go on longer the greater the proportion of hydrochloric acid which passes into the combined form; in other words, the presence of a large amount of proteid in the food is favourable to the digestion of starch in the stomach, whereas if the meal consists exclusively of carbohydrates the process must sooner come to an end. This is one of the many advantages of a mixed diet.

Relation of the Acidity of the Stomach Contents to Morbid Gastric Sensations.

In health digestion proceeds quite unconsciously, and without the production of any sensation at all. In morbid conditions of the

[1] *Deut. Archiv. f. Klin. Med.*, liii. 209, 1894.

[2] See Gillespie, *op. cit.*, p. 157; Aitchison Robertson, *Edinburgh Medical Journal*, May, 1896; A. E. Austin, *Boston Medical and Surgical Journal*, April 6, 1899.

stomach, however, digestion may be accompanied by sensations of pain, and these seem to arise in at least two ways: (1) from disorder of the motor functions of the stomach; (2) from abnormal conditions of the mucous membrane.

The former of these we shall consider later. The latter seems to be of two sorts: (*a*) where the mucous membrane is unduly sensitive to the *total acidity* of the contents; (*b*) where *free* acid alone produces pain. The former of these conditions seems to be present where actual lesions of the mucous membrane exist—*e.g.*, in ulcer and in carcinoma; the latter is apparently more often of the nature of a neurosis—a hyperæsthesia of the nerves of the mucous membrane, though it is possible that in extreme degrees of such hyperæsthesia pain may be produced even by combined acid. Where the total acidity causes pain the condition is likely to be aggravated by foods rich in proteid, such as meat, for these, as we have seen, call forth an abundance of juice, and therefore of acid. If, on the other hand, free acidity alone excites the sensation, such foods are likely to be beneficial, for they delay the period at which free acid appears, and also lessen its amount. In accordance with this explanation, I think it will be found that patients who are suffering from ulceration of the stomach complain of pain after meat, but can digest milk with comfort; for milk not only neutralizes much acid by means of its bases, but in itself calls out the secretion of a weak and scanty gastric juice. On the other hand, one usually finds that patients with functional dyspepsia and hyperæsthesia of the stomach suffer less from meat than from foods which, being poor in proteids, allow of the early appearance of uncombined hydrochloric acid. These considerations are of importance in helping one to select a suitable dietary for dyspeptics.

Movements of the Stomach.[1]

In studying the movements of the stomach, one must distinguish quite sharply between the cardiac and the pyloric end of the organ. There is no doubt that this distinction is not grasped as clearly as it ought to be. The two ends are distinct, both anatomically and functionally. The cardiac end secretes both pepsin and hydrochloric acid, the pyloric end pepsin alone. The former has but feeble motor power; the movements of the latter are frequent and

[1] See Beaumont, 'Experiments and Observations on the Gastric Juice and on the Physiology of Digestion,' Edinburgh, 1838; Moritz, 'Studien über die Motorische Thätigkeit des Magens,' *Zeit. f. Biol.*, xxxii. 313, 1895, and *Münch. Med. Wochensch.*, No. 38, 1893, and No. 41, 1894; Roux and Balthazard, 'Motricité Stomacale,' *Arch. de Physiol.*, 5th series, x. 85, 1898.

powerful. This functional difference would be found, I think, to explain to some extent the respective liability of the two ends to different diseases, but that subject cannot be entered upon here.

Nor is it commonly recognised that the two portions of the stomach are separated from each other by a thickening of the muscular coat, which acts as a kind of 'pre-pyloric sphincter.' The existence of this sphincter was long ago pointed out by Retzius.[1] It is situated at a variable distance from the pylorus, and, though it cannot always be demonstrated post-mortem, it is probably always present in the living organ. Thanks to the existence of this sphincter, the stomach is able to 'sort' its con-

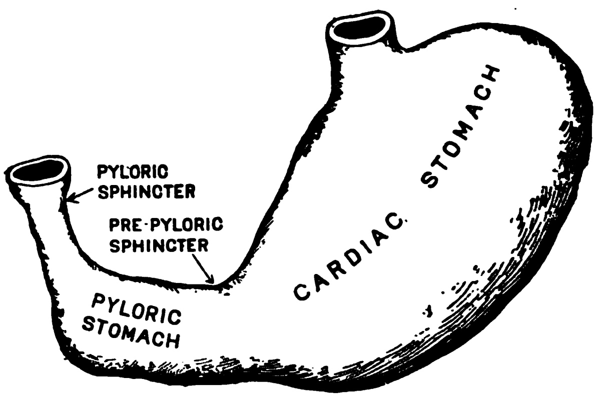

FIG. 33.—SHOWING THE DIVISION OF THE STOMACH INTO TWO PORTIONS. (DRAWN FROM A DISSECTING-ROOM SPECIMEN.)

tents into those which are in a fit state to be passed on into the intestine, and those which must be kept back to be further acted upon by the gastric juice. The sorting is probably brought about in this way: Shortly after the food enters the stomach feeble peristaltic waves are set up in the cardiac end, which keep up a slow revolution of the contents, sufficient to ensure their complete mixing with the gastric juice, but not of sufficient strength to exercise any real pressure on the food masses such as might break them up mechanically. These waves seem to stop at the pre-pyloric sphincter, their point of cessation being marked in the living stomach by the appearance of a transverse sulcus. They are strong enough to squeeze the fluid part of the contents past this constriction on into the pyloric end, but are not sufficiently powerful to do the same for solid, undigested lumps. In this way the digested

[1] *Muller's Archiv.*, 1857, p. 74. He describes the 'pre-pyloric sphincter' as the 'sphincter antri pylori.'

parts of the food are separated from the rest. The pyloric end now proceeds to contract at intervals of about three to the minute, the contractions being rather of the nature of a systole than of a peristalsis. At each contraction the pylorus opens, and a gush of chyme into the duodenum takes place. Should any solid masses find their way into the pyloric end, they seem to cause a spasm of the pylorus, and are squeezed back again through the pre-pyloric sphincter into the cardia to undergo further solution. The occurrence of this was frequently noticed by Beaumont in his classical observations on Alexis St. Martin. Whenever the bulb of a thermometer was passed down into the pyloric end, it was firmly grasped, and then projected upwards with a sudden, twisting movement, the process being accompanied by pain and a feeling of nausea and faintness. Attacks of 'gastralgia' are no doubt often produced in this way by the passage of solid masses of food into the pyloric end of the stomach, and such muscular pain must be distinguished from pain having its seat in the mucous membrane, the possible modes of production of which have already been considered. Hot fluids and the volatile oils and ethers found in good brandy and in certain old wines seem to have a great power of relieving this cramp-like pain, probably by unlocking the pylorus and allowing of the escape of the undigested masses.

The activity of **the peristaltic movements of the stomach** seems to depend in part on the temperature of the contents, and in part on their chemical nature. Mere mechanical contact seems to have but little stimulating effect upon them. Hot food increases the frequency and vigour of the movements, and so does a highly acid condition of the contents. It may be for this reason that the movements become more vigorous as digestion proceeds. Such stimulating substances as mustard, alcohol and carbonic acid gas seem to have a similar effect.

The length of time which elapses between the swallowing of food and the first opening of the pylorus is variable, depending chiefly upon the consistence of the food and the temperature and reaction of the stomach contents. Fluids, unless they contain much solid matter in solution, begin to escape almost immediately, water, indeed, whilst it is still being swallowed.

Any excess of fluid taken with a solid meal is probably also passed on almost at once, and so cannot seriously dilute the gastric juice. Solid food can only escape after it has been reduced to a fluid or semi-fluid consistency, and this must obviously depend to a large extent upon its physical characters and density.

Busch, in his observations upon a patient with a duodenal fistula, saw the escape of food after as short an interval as fifteen or thirty minutes.[1]

The larger part of a meal, however, probably does not pass out of the stomach till most of it has been completely digested, and half an hour after that has taken place the stomach may be regarded as empty.

Warmth tends to accelerate the opening of the pylorus, but a very acid condition of the stomach contents has a contrary effect. Organic acids have perhaps a more powerful influence in this direction than hydrochloric acid, and may induce an actual spasm of the orifice. A dose of alkali may relieve the pain which such spasm causes. Hence it is only towards the close of digestion, when the acidity of the stomach contents has been reduced by the addition of the neutral or slightly alkaline secretion of the pyloric end, that the conditions most favourable to the escape of food come into existence. There is reason, also, to believe that the duodenum exercises a controlling influence over the pylorus, distension of it inhibiting the opening which would otherwise take place.

Rate of Digestion of Different Foods.

Seeing that food cannot be passed on into the intestine until it has been brought into a state of solution, it is obvious that we have, in the period which elapses before the stomach is empty after the taking of any particular article of diet, a criterion of its digestibility as far as the stomach is concerned. In previous chapters the relative digestibility of different foods has been considered in detail, but it may be well at this point to summarize our knowledge of the subject.

Most of our information on this matter has been derived from the experiments of Penzoldt on healthy men.[2] He found, as might have been expected, that the amount and consistency of the food have a strong determining influence in the rate of digestion. Fluids escape most rapidly of all. Thus, 7 ounces (200 c.c.) of water have entirely left the stomach in one and a half hours,[3] and tea, coffee, and alcoholic liquors in the same time. Hot drinks, contrary to what might have

[1] *Virchow's Archiv.*, xiv. 140, 1858.

[2] *Deut. Archiv. f. Klin. Med.*, li. 535, 1893. The experiments of Beaumont are of very little value, owing to the fact that they take no account of the amount of food given.

[3] The time was always calculated from the moment at which the food had begun to be swallowed.

been expected, did not seem to leave sooner than cold, nor did the *quantity* of fluid make much difference, so that it scarcely matters, as regards stay in the stomach, whether one takes 3 or 6 ounces of fluid. On the other hand, the presence of solid matter in solution or suspension in the fluid caused it to remain longer, but not much, 7 ounces of boiled milk staying about two hours. Meat-juices, and water containing in solution such substances as peptone, did not remain any longer than ordinary water or milk. Aerated water was found to remain in the stomach for an even shorter time than plain water, probably because the carbonic acid which it contains accelerates the stomach movements.

As regards solids, digestibility is influenced much more by consistence than by amount. An increase in the quantity taken prolongs, it is true, the duration of stay in the stomach, but not proportionally. Doubling the amount eaten, for instance, does not mean doubling the length of time required for digestion. In the case of meat, to take an example, an addition of 50 grammes caused only an increase of one hour in the time required for complete digestion, and in the case of biscuits a similar addition produced an extra delay in the stomach of only seventy minutes. Put otherwise, six times the original quantity of beef requires only three times the original amount of time taken by digestion; in the case of biscuits, four times the original quantity requires double the time, while with fluids the original quantity can be increased five times while only doubling the original time.

Of animal foods, the most rapidly digested were those of a soft consistence, such as sweetbread. The white meats, *e.g.*, chicken, were more digestible than dark, *e.g.*, duck, or even the red meats, but the method of cooking had great influence on the result. Fresh fish, in his experiments, was more rapidly digested than meat.

As regards vegetable foods, the consistency and the amount of solid matter contained were again the ruling factors. Thus, 'mealy' potatoes were more rapidly disposed of than 'waxy,' and in purée more easily than when in pieces. Fine bread and biscuits were found to be more digestible than coarse bread, but there was not much difference between crust, crumb and toast, or even between new and stale bread, provided all were equally well chewed. Cauliflower was the most rapidly digested of vegetables.

The following table contains a summary of these results in greater detail, along with the fuel value of the quantity of each article employed:

TABLE SHOWING RATE OF DIGESTION OF DIFFERENT FOODS AND THEIR CALORIE VALUE.[1]

Leave Stomach in 2 to 3 Hours.

Food.	Calories in Form of: Proteid.	Carbohydrates.	Fat.	Total Calorie Value.
400 c.c. (14⅛ ounces) boiled milk ..	57·4	78·8	137·6	273·8
100 grammes egg, raw, poached, or omelette (=about two eggs)	51·7	2·1	112·5	166·3
100 grammes beef sausage (3½ ounces) ..	59·7	—	372·0	431·7
200 ,, sweetbread (7 ounces) ..	229·6	—	0·4	230·0
72 ,, oysters (10 of moderate size)	17·7	10·7	7·7	35·1
200 ,, white fish (7 ounces) ..	179·6	—	20·5	200·1
200 ,, shell-fish ,, ..	139·4	—	9·3	148·7
150 ,, asparagus (5⅓ ounces) ..	12·3	12·3	—	24·6
100 ,, white bread (3½ ounces or 1½ slices)	28·7	213·2	4·6	246·5
100 grammes rusks..	35·3	307·9	9·3	352·5
50 ,, biscuit (1¾ ounces).. ..	21·4	150·0	21·4	192·8

Leave Stomach in 3 to 4 Hours.

Food.	Calories in Form of: Proteid.	Carbohydrates.	Fat.	Total Calorie Value.
230 grammes chicken (8¼ ounces) ..	188·6	—	85·6	274·2
250 ,, lean beef (9 ounces) ..	215·2	—	34·8	250·1
160 ,, boiled ham (6 ounces) ..	157·4	—	535·7	693·1
100 ,, roast veal (3½ ounces) ..	82·0	—	13·9	95·9
100 ,, beefsteak ,, ,, ..	140·3	—	76·4	216·7
100 ,, salted caviare (3½ ounces)	127·1	—	148·8	275·9
150 ,, coarse bread (5⅓ ounces) ..	36·9	307·5	6·9	351·3
150 ,, boiled rice ,, ,, ..	18·5	467·4	—	485·9
150 ,, boiled cabbage (5⅓ ounces)	18·5	49·2	—	67·7

Leave Stomach in 4 to 5 Hours.

Food	Calories in Form of: Proteid.	Carbohydrates.	Fat.	Total Calorie Value.
250 grammes smoked tongue (9 ounces)..	247·0	—	721	96·8
100 ,, smoked beef (3½ ounces) ..	110·7	—	139·5	250·2
250 ,, roast goose (9 ounces) ..	164·0	—	106·0	122·4
200 ,, salt herring (7 ounces) ..	154·9	12·3	314·3	481·5
150 ,, lentil porridge (5⅓ ounces)	153·7	332·1	—	485·8
200 ,, pease porridge (7 ounces)..	188·6	426·4	—	615·0

One may compare with these observations those of Verhaegen,[2] who concludes from a large number of experiments that—

½ litre boiled milk leaves the stomach in 2½ hours.
1 ,, ,, ,, ,, 3½ ,,
100 grammes of bread leave the stomach in 3 ,,
150 ,, ,, ,, ,, 4 ,,
100 ,, ,, and 60 of meat leave the stomach in 4 hours.
An ordinary dinner leaves the stomach in 4 to 5 hours.

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[1] Modified from Strauss, *Zeit. f. Diät. Therapie*, iii., Heft 4, and based on the results of Penzoldt (*Deut. Archiv. f. Klin. Med.*, li. 535, 1893).

[2] 'Physiologie et Pathologie de la Sécretion Gastrique,' Paris, 1898.

Leube[1] divides foods into four groups, according to the ease with which they are digested, the first group containing those which are most digestible:

1. Beef-tea, solution of meat (Leube-Rosenthal), milk, soft or raw eggs, Albert biscuits.
2. Boiled calves' brains, sweetbread, boiled fowl, pigeon or calves, feet.
3. Scraped underdone steak, potato purée, stale bread.
4. Roast chicken or pigeon, roast veal, cold roast beef (underdone), white fish, macaroni, rice, chopped spinach.

A study of all these results will enable one to select the most suitable foods for persons of weak digestion.

3. **Antiseptic Action of the Gastric Juice.**—Another function which the stomach serves is that of partially sterilizing the food by the antiseptic action of the hydrochloric acid of the gastric juice. This action, however, is not a powerful one, and some organisms, such as those that form acids, seem to escape it altogether, and there is reason to believe that the same is true of some, at least, of the commoner pathogenic organisms, notably the tubercle bacillus.

The sterilizing power of the stomach must vary greatly according to the period of digestion and the nature of the food. It probably reaches its maximum towards the later periods of digestion, when hydrochloric acid is present in the free state, whilst it is much less, or even absent altogether, in the earlier stages, when all the hydrochloric acid is in a combined form. Food rich in proteid, by fixing the hydrochloric acid, must greatly lessen the germicidal power of the gastric juice. Over the growth of organisms in the intestine the stomach seems powerless to exert any control. Even in cases in which the secretion of hydrochloric acid is entirely arrested, or in which the stomach has been completely removed, no increase in the amount of intestinal putrefaction was found to occur.[2]

4. **The Temperature of Foods and Drinks.**[3]—One of the minor functions of the stomach is that of regulating the temperature of the food. It stands in this matter as a protector of the intestine, which appears to be more injuriously affected by extremes of temperature than the stomach itself.

The ideal temperature for food is probably that of the body itself.

[1] *Zeit. f. Klin. Med.*, vi. 189, 1883.
[2] See Schlatter, *Lancet*, January 15, 1898, and Filippi, *Deut. Med. Wochensch.*, No. 40, 1894.
[3] See Späth, *Archiv. f. Hygiene*, iv. 68, 1886, and Uffelmann, *Wiener Klinik*, xiii., Heft 9, 1887.

Cold food is difficult to digest, for it does not excite the stomach sufficiently, nor does it possess the stimulating properties of a hot meal. It has been observed that there is a special craving for alcoholic stimulants on the part of those who are unable to get hot meals.

Extremes of temperature in foods should be avoided as tending to produce local injury to the stomach; from 45° to 130° F. are probably the limits of safety.

Drinks at a temperature of 122° F. are sufficient to warm the body, and a temperature of 45° F. is sufficient to cool it. Wunderlich[1] found that hot punch at 122° F. raised the temperature of the body by 0·1° to ·03° C. for a period of thirty to sixty minutes, while half a litre of water at the same degree of heat caused an acceleration of the pulse by nearly 20 beats per minute very shortly after it had been swallowed.

On the other hand, three tumblerfuls of water at a temperature of 45° F. produced a lowering of the axillary temperature from 98·4° F. to 97·7° F., while the pulse-rate fell from 70 to 61 per minute.

Violent alternations in the temperature of foods seem to cause fissuring of the enamel of the **teeth**. Uffelmann, for instance, placed recently-extracted teeth in water first at 65° C., and then directly afterwards at 6° C., and in nine out of eleven cases he produced some degree of splitting of the enamel.

The **local effects of extremes of temperature** in the stomach are very much the same whether the extreme be one of heat or of cold. In each case there is a danger of exciting gastric catarrh. Very hot foods seem to be specially dangerous in stomach-bleedings, *e.g.*, ulcer; and there are some who say that the special liability of cooks to suffer from gastric ulcer is to be attributed to their constantly tasting very hot foods. On the other hand, very warm fluids may relieve pain in the stomach by abolishing pyloric spasm.

The temperature most suited for drinks intended **to quench thirst** is one of from 50° to 70° F. Ices should be avoided, as they may cause dyspepsia, cardialgia, and even acute dilatation of the stomach, although small quantities of ice undoubtedly tend to allay gastric irritability. It must also be remembered that the drinking of very cold water when one is heated may bring about a reflex congestion of the lungs, and there is certainly reason to believe that diabetes sometimes owes its origin to a similar cause.

5. **Absorptive Power of the Stomach.**—The absorptive power of the stomach is surprisingly small. In this also one may see

[1] Quoted by Uffelmann.

a provision for the protection of the body, for it allows of the neutralization or rejection of injurious substances before they have time to enter the blood. Alcohol, curiously enough, is of all substances that which the stomach absorbs most readily. This explains to some extent the rapid stimulating action of alcohol. Peptone, sugars and salts, are also absorbed by the stomach to some extent. The stronger the alcohol, or the more concentrated the solution of these substances, the greater is the degree of absorption.

There is reason to believe that the process of absorption by the stomach is much more of the nature of a mere physical osmosis than is the case in the intestine, and the process is accompanied by the pouring out of a good deal of secretion. It is in this way, perhaps, that a mixture of alcohol and sugar, such as is found in sweet wines and some malt liquors, may cause 'acidity.' The practical bearings of absorption in the stomach will be more fully dealt with, however, when we come to consider the dietetic treatment of gastric dilatation.

Digestion and Absorption in the Intestine.

When the food has passed through the pylorus, it enters the duodenum and encounters the secretion of the pancreas. The anatomical disposition of the duodenum seems specially designed to favour complete mixing of the chyme with the pancreatic juice, for the duodenal loop forms a kind of U-tube, in which some delay of the contents may be expected to take place. The degree of distension of this loop seems to have some influence, too, over the opening of the pylorus, so that as long as the duodenum is full no further escape of food from the stomach takes place.

The chief stimulant of the pancreatic secretion is the hydrochloric acid, which reaches it from the stomach; the psychical factor, though active, is not nearly so potent as in the case of gastric secretion. The chemical constituents of the food also have an influence, just as they have in the case of the stomach, fat especially calling forth an abundant secretion. As the pancreatic juice is the chief agent concerned in the digestion of fat, we see in this again a wonderful adaptation of means to ends. Starch, on the other hand, has no great effect beyond that of producing a slight increase in the amount of the sugar-forming ferment.

Of the disorders of pancreatic digestion we know but little, though they are probably of less importance than those of the stomach, for the reserve power of the pancreas seems to be so great that it is quite

equal to digesting the whole of the food itself should the stomach be unable to perform its share in the process. The importance of this for dyspeptics is very great.

As the food passes along the intestine absorption of its ingredients takes place, and the degree to which this occurs in different foods has already been fully considered (p. 9).

The influence of each constituent of the food on the absorption of others is probably of considerable importance, though not much is known about it. The addition of starch to proteid, for example, tends to diminish somewhat the absorption of the latter, whilst fat starvation tends to lessen the absorption of phosphoric acid.[1] On the other hand, if fat is not being well absorbed, as, for example, in cases where the bile cannot enter the duodenum, one finds that the destruction of proteids by putrefaction is greatly increased, owing to the unabsorbed fat enclosing the particles of proteid and interfering with their proper digestion. This furnishes an additional reason for interdicting fat in jaundice. The increase of intestinal putrefaction brought about in this indirect way no doubt led to the erroneous idea that bile is an antiseptic. Seeing that the influence of the carbohydrates is rather to retard the putrefaction of proteids, it is obvious that fats cannot replace the former as far as the intestine is concerned.[2]

The **rôle of bacteria** in intestinal digestion has sometimes been minimized, at others exaggerated. There is no doubt that they are not indispensable for the occurrence of digestion. On the other hand, they play a useful part in restraining putrefaction. The only bacteria which flourish in the small intestine are those which are capable of forming acids (*e.g.*, acetic, lactic, and succinic) out of carbohydrates. The acids so produced tend constantly to be neutralized by the alkaline secretion of the intestinal mucous membrane, but in the struggle which thus takes place the acids always maintain the upper hand, and consequently the contents of the small intestine have an acid reaction throughout. Thanks to this slight degree of acidity, the growth of putrefactive organisms is restrained, and the destruction of proteids especially prevented. Hence, if one wishes to diminish intestinal putrefaction, the diet must contain carbohydrates, for it is only out of these that acids can be produced. This explains the very fœtid nature of the stools passed by patients who are being fed exclusively on lean meat. It may be well also to

[1] *Journal of Experimental Medicine*, iii. 293, 1898.
[2] See Laas, 'Uber den Einfluss der Fette auf die Ausnutzung der Eiweisstoffe,' *Zeit. f. Physiol. Chem.*, xx. 233, 1894.

remind the reader again at this point of the value of milk as an intestinal antiseptic (see p. 122).

It is important to remember that the contents of the small intestine remain fluid throughout its entire length. Even at the lower end of the ileum the amount of solid matter is only 5 to 10 per cent. The advantages of a fluid diet in intestinal ulceration, therefore, can scarcely be due to any less degree of mechanical irritation on the part of fluid food.

In the **large intestine** the contents of the bowel are brought to a solid form, mainly by the absorption of water. The absorptive power of the large intestine for the nutritive constituents of the food will be considered in another chapter.

The investigation of Prausnitz[1] has shown that the **fæces** are to be regarded as chiefly composed of the remains of the digestive juices, and that their composition is very uniform, the chief ingredients (in the dried form) being

Nitrogen	8 to 9 per cent.
Ether extract	12 to 18 ,,
Mineral matter	12 to 15 ,,

The fæces of a mixed diet always contain muscle fibres, but starch is completely absorbed unless pulses or green vegetables are largely eaten.

If the diet is of such a nature that much cellulose and some starch are excreted, the percentage of nitrogen falls. If, on the contrary, the absorption of nitrogen is deficient, the percentage of that ingredient rises. Other things being equal, therefore, a low percentage of nitrogen in the fæces indicates bad general absorption of the food, while a high proportion of nitrogen has a contrary significance.

The bulky fæces of a vegetable diet are largely due to the presence of an excess of moisture, which has been poured out by the walls of the bowel in the attempt to neutralize organic acids produced by fermentation.

In the large intestine, the putrefactive bacteria are able to flourish, for the absorption of carbohydrates higher up renders the further production of acids which restrain putrefaction impossible.

The following **summary of the digestion of a mixed meal** may serve to gather up a number of the scattered facts which have been mentioned in the preceding paragraphs:

The complex sensation called 'hunger' impels one to seek food. The sight and smell of the food awakens the sensation of 'appetite,'

[1] *Zeit. f. Biologie*, xxxv. 287, 1897.

and with it there begins a flow of digestive juices, most marked in the case of the stomach. The warm soup, which usually forms the first course, passes straight into the stomach, and, in virtue of its warmth and of the gelatin and extractives which it contains, accelerates and increases the secretion of the gastric juice. The solid part of the food is reduced to a pulp in the mouth, and, unless acid substances are mixed with it, part of its starch is changed into sugar. Arrived in the stomach, it encounters the 'psychical' juice already secreted, the acid of which is immediately laid hold of by the proteids of the food. In this way the acidity of the stomach contents is kept down, and the action of the saliva upon the starch is allowed to continue. As the solids become dissolved by the 'psychical' juice, their chemical constituents are set free, and themselves begin to excite a specific secretion specially fitted for their own digestion.

Meanwhile, the acidity of the contents goes on increasing, and soon brings to an end any further action of the saliva upon starch, and kills or paralyzes many of the organisms swallowed with the food, while at the same time the peristaltic movements of the stomach are excited. Under the influence of these the gastric juice and the food are intimately mixed, and the temperature of the mass gradually adjusted to that of the body. As solution proceeds, the semi-fluid part of the contents along with any excess of fluid which has been swallowed finds its way into the pyloric end of the stomach, and by the systolic contractions of the latter is propelled into the duodenum. This process continues for about four or five hours, by the end of which time the stomach is again empty. During all this time the absorption of alcohol and small quantities of peptone, sugar, and salts has been taking place.

Arrived in the duodenum, the food encounters the secretion of the pancreas already called out by psychical influences, and now increased by the stimulus of the acidity of the stomach contents and by the specific chemical action of the constituents of the chyme, especially by that of fat. Here digestion is completed, and as the food sweeps along the small intestine its constituents are rapidly absorbed into the blood, or chyle. During this time certain bacteria, which have escaped the action of the gastric juice, are busy breaking up any carbohydrates which may be present, producing from them organic acids, which restrain the putrefaction of the proteid constituents of the food which would otherwise be apt to occur. The fluid poured out by the glands of the small intestine in the attempt to neutralize these acids more than makes up for any absorption of water, and causes the contents of the ileum to remain fluid until the

large intestine is reached. Beyond this point the production of acids ceases, and the rapid absorption of water causes the contents to assume a solid form, while putrefactive bacteria are able to grow unchecked, save by the products of their own activity. Finally the residue is expelled in the form of fæces, usually about twenty-four hours after the food was first swallowed.

The respective **influence of exercise and rest** on the processes of digestion is disputed. Beaumont, from his observations on St. Martin, came to the conclusion that *gentle* exercise aided digestion, but the experiments of Fleischer[1] gave a contrary result. The whole question is probably one of blood-supply. Gentle exercise, by increasing the rapidity of the circulation, may aid the secretion of digestive juices and stimulate the movements of the stomach. Severe exercise, on the other hand, by diverting much blood and nervous energy to the muscles, may be expected to have an adverse effect. Sleep is only useful as an aid to digestion in the case of invalids and aged persons, but even in them it may be injurious, probably on account of the depression of the circulation by which it is accompanied.

On the whole one can agree with King Chambers, that the best employment after a heavy meal is 'frivolous conversation,' which keeps the heart active without making great demands upon the brain.

[1] *Berlin. Klin. Wochensch.*, No. 7, 1882.

CHAPTER XXIV

THE PRINCIPLES OF FEEDING IN INFANCY AND CHILDHOOD: HUMAN MILK

I. Physiological Requirements in the Diet of Infancy.

A healthy infant spends most of its time in sleeping and growing. Its muscular efforts are confined to a little sucking, more or less crying, and some kicking. Hence it follows that the diet of an infant should contain relatively more of the tissue-builders (proteids and mineral matters), and relatively less of the energy-producers (carbohydrates), than one finds in the food of the adult. Like all small animals, too, the infant has a large extent of surface in proportion to its bulk; thus it tends to lose heat rapidly, and requires an abundant supply of the chief body fuel—fat. If these different ingredients are not supplied in due proportion, disorder of health inevitably follows. If the tissue-builders are not sufficiently represented, the muscles, blood, and bones are not properly formed, and the child becomes flabby, pale, and rickety. On the other hand, if the supply of proteid is in excess of the child's digestive and assimilative powers, it suffers from disorder of the stomach and bowels. If it be an infant, curdy stools will be passed, and there will be a tendency to diarrhœa. Older children will suffer from indigestion, irritability, and restlessness. A sufficient supply of fat is of even greater importance. Indeed, it may be said that **abundance of fat** should be the main characteristic of the diet of infancy, just as abundance of carbohydrates is the chief feature of the diet of adult and laborious life. The fat serves as fuel. Without it the child has difficulty in maintaining the proper temperature of its body, and is liable to catarrhs of the lung or bowel. In addition to this great use, fat seems, during the period of rapid growth, to be itself a tissue-producer. The infant is laying down a considerable amount of tissue rich in fat in the marrow of its bones and in its nervous

apparatus, and it may well be that the fat of the diet aids in the production of such tissues. Of this, at any rate, there can be no doubt, that a child whose diet is deficient in fat rapidly loses vigour and is extremely prone to suffer from rickets. The frequent connection between rickets and deficiency of fat in the food is an undeniable clinical fact, of which, however, it is difficult to give a satisfactory explanation. Experiments have been made[1] in which young animals were fed on separated milk practically free from fat; but although the absorption of phosphoric acid by them was found for some reason or another to be much interfered with, yet they did not suffer from rickets.

Important though an abundant supply of fat is, one must take care not to give it in excess, for under these circumstances it is a frequent cause of vomiting and diarrhœa in young infants. A milk which contains more than 6½ per cent. of fat may always be expected to produce these results.

Carbohydrates are, as we have seen, not of so much importance in the dietary of infancy as in that of older children or the adult. They are important, however, not only as making provision for what muscular effort the child does display, but also in their capacity as proteid-sparers (p. 22). If there is a due supply of sugar in the diet, it is reasonable to suppose that less proteid will suffice. The carbohydrates, however, are the ingredient of the diet which is least likely to be represented in too small amount. On the contrary, there is a much greater danger of supplying them in excess, or of making them a substitute for fat. An infant which is the victim of such an error may be plump enough, but its muscles are flabby, its skin pale, and its bones often rickety. It is the false appearance of good nutrition which such infants often possess that is apt to deceive the uninitiated, and such children have been known to receive prizes at baby-shows, when all the time they were undoubtedly the subjects of rickets. It must be remembered, too, that carbohydrates, especially when given in excess and in unsuitable forms, such as starch or cane-sugar, are very prone to undergo fermentation in the stomach and intestine of the infant, whereby acids are produced and griping and diarrhœa result.

The **mineral ingredients** of the food in infancy are equal in importance to the proteids. Like these, they are concerned in building up the child's body, and deficiency of them will produce much the same symptoms as deficiency of proteids. Salts of lime, potash, and phosphoric acid are specially important. Phosphate of

[1] *Journal of Experimental Medicine*, iii. 293, 1898.

lime is wanted for the bones, and phosphate of potash for the muscles and blood. It must not be supposed that it is a matter of indifference in what form these are supplied. It would seem that these salts are of much greater use when they enter the body in combination with organic matter than they are in a free mineral form. Milk, and especially human milk, is peculiarly rich in organic combinations of these salts, and for this reason lime-water or chemical preparations of salts can be no proper substitute for it. On the other hand, there is no reason to believe that the presence of an excessive quantity of mineral matter in the food of an infant does any harm; the child simply does not absorb or assimilate more of each compound than it requires for building or other purposes.

The importance of **water** to the infant will be evident when one recollects that more than three-fourths of the whole body consists of it, and that it constitutes about four-fifths of milk, which is the natural diet of infancy. Water has also local uses in the stomach and bowels, promoting as it does the processes of absorption and secretion. One is too apt to forget that an infant may suffer from thirst as well as from hunger, and that water will allay the former better than milk. The effect of a drink of cold water is certainly always worth trying if a child is suffering from evident but unexplained discomfort.

2. Human Milk: its Composition and Variations.

We have spoken on the one hand of the importance of a due supply of each nutritive ingredient in the diet of the infant, and on the other of the danger to health which results if any one of them be present in excess. One naturally turns to human milk, the natural food of infants, for guidance as to the proper quantity of each ingredient to be supplied, and for this reason the study of its exact chemical composition is of the first importance. If one surveys the records of the chemical analyses[1] of human milk which have been made, one is struck both by the enormous amount of work which has been done on the subject, and at the same time by the discrepancies in the results of different observers. These discrepancies are to be explained partly by technical difficulties in milk analysis, and partly by the fact that the milk of one woman may differ not only from that of another, but may also show variations from day to day and at different periods of nursing.

[1] For a review of analyses of human milk, see Blauberg, 'Experimentelle und Kritische Studien über Säuglingsfäces,' Berlin, 1897, and Hauser, *Fortschr. der Med.*, Bd 15, No. 24, 1897.

The following[1] represents the results of the latest and most trustworthy **analyses of human milk**, taken about the middle of the second week of nursing:

Specific gravity	1032
Water	87·75 per cent.
Solids	12·25 "
Proteid	1·62 "
Fat	3·14 "
Milk-sugar	6·26 "
Mineral matter	0·27 "
Citric acid	0·05 "
Unknown extractives	0·91 "
Reaction	Alkaline.

A healthy woman produces 700 to 2,000 grammes (1¼ to 4 pints) of such milk daily, although the former figure would be much nearer the average than the latter.

I should like to direct special attention to two points in the above analysis: Firstly, to the small amount of proteid which human milk contains, and, secondly, to the presence of a considerable proportion of 'extractive' matters. These are admittedly of unknown nature, but they contain nitrogen. The earlier analysts classed them amongst the proteids, and hence overstated the amount of the latter which human milk contains. Furthermore, the above analysis must only be taken as representing the average composition of human milk. Considerable variations are met with, the causes of which may be considered under the following heads:

1. *Variations dependent on the Period of Suckling.*—One might naturally expect that an infant a few days old would not require the different ingredients of milk in exactly the same relative proportions as one of some weeks, and chemical analysis of milk at different periods of lactation verifies the expectation.

The milk secreted during the first two or three days after the birth of the child is called **colostrum**, and has some peculiar characters. It is more watery-looking than ordinary milk, and contains a special form of proteid, which causes it to clot on boiling for the first day or two. The actual amount of proteid which it contains is greater than in ordinary milk, though the exact figures given by different analysts vary on the point, some placing the amount of proteid as high as 8 per cent. The following table contains the average of a number of samples of colostrum analyzed by Woodward:[2]

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[1] Analysis by Camerer and Söldner, *Zeit. f. Biolog.*, Bd. 33, p. 535, 1896.
[2] *Journal of Experimental Medicine*, ii. 217.

Specific gravity	1024 to 1034 (variations due to differences in the amount of fat)
Water	87·5 per cent.
Proteid	1·9 ,,
Fat	4·0 ,,
Sugar	6·5 ,,
Mineral matter	0·2 ,,

Colostrum may contain a number of peculiar microscopic cells called colostrum corpuscles, the number of which is very variable. As they consist of proteid, they must be of some nutritive value to the child. One of the uses of colostrum appears to be as a laxative, causing the expulsion from the intestine of the child of a quantity of waste matter with which it comes into the world.

After the third day the ordinary milk begins to be produced, and the changes which it undergoes in composition from this period onwards are exhibited in the following table:

INFLUENCE OF PERIOD OF LACTATION ON COMPOSITION OF HUMAN MILK.[1]

Period.	*Total N.*	*Proteid.*	*Fat.*	*Sugar.*	*Ash.*	*Increase in Child's Weight per Day.*
5th day	0·33	2·0	2·8	5·4	0·34	35 to 40 grammes
8th to 11th day	0·27	1·6	3·1	6·2	0·27	
20th ,, 40th ,,	0·20	1·1	3·8	6·4	0·22	
70th ,, 120th ,,	0·17	1·0	2·9	6·7	0·20	22 ,,
170th and after	0·14	0·8	2·6	6·8	0·19	18 ,,

A study of it will show that on the whole the building material (proteid and mineral matter) tends to become less in amount as lactation proceeds, the sugar rises rapidly up to the end of the second week, and after that more slowly, while the fat, after reaching a maximum about the second month, tends to fall off again in the later periods.

A little consideration will show that these variations are very much what one would expect from the physiological requirements of the infant at different ages. During the first few weeks of life the child grows much faster than subsequently. The last column of the table shows that in the first month from 35 to 40 grammes are added to the weight each day, while by the time the sixth month is reached the daily increase in weight has fallen to 18 grammes. Obviously, then, the infant will require relatively more building material at the former period than at the latter. The gradual increase in the proportion of carbohydrate is also just what one would expect in view of the daily increasing muscular activity of the child.

A general consideration of the table clearly shows that the milk of

[1] From analyses by Camerer and Söldner, *Zeit. f. Biolog.*, xxxiii. 43, 535, 1896; increases in weight from Pröscher, *Zeit. f. Physiolog. Chem.*, Bd. 24, p. 285, 1897.

the mother certainly does not get richer as the child gets older, but that the increasing demand for nutriment by the growing infant is met by supplying an increased quantity of milk, and not by providing an improved quality.

This fact should be noted by those who have to provide artificial substitutes for human milk. It follows, also, that there is some scientific justification for the popular view that a wet-nurse should not suckle a child which is much younger than her own. The difference, however, between the composition of milk at the third week and third month is not sufficiently great to make such a difference between the ages of the two infants a bar to the employment of the nurse.[1]

2. *Variations dependent on Individual Differences in the Mother or her Child.*—These are of comparatively little importance. It has been found that as a matter of fact the milk of any given woman will show greater variations from day to day than one finds on comparing the milk of different women on any one day. Weak women, also, seem to furnish as good a milk as those who are robust and strong, and the milk of women who have borne many children is but little poorer than that of those who are nursing their first infant. Age, also, has little influence, for the milk of women approaching the climacteric has not been found inferior to that of mothers hardly out of their teens. Illness, menstruation, pregnancy, fever, and even severe emotional disturbance, are also almost entirely devoid of any appreciable effect on the composition of the milk. The most striking fact about the composition of the milk, indeed, is its independence of outside influences.[2]

The fact that a woman has a feeble child is no proof that the milk is at fault. On the contrary, it was found that the milk of women with feeble infants was rather richer than when the suckling was robust. It would almost seem as if there was here a provision of Nature to supply the child which has only strength to draw a small *quantity* of milk with a food of proportionately better quality.

[1] See also Baumm and Illner, *Samml. Klin. Vorträge* (*Gynäk.*), xli., 1894. These observers found considerably less difference in the composition of the milk at different periods than was shown in the later work of Camerer and Söldner. Monti (*Wiener Klinik*, Jahrg. xxiii., Hft. 1, 2, 3, 1897) says that a child from one to six weeks old should have a wet-nurse whose child is not more than two months. A child from two to four months requires a nurse who has not been suckling for more than three to four months. Whether for older babies a younger nurse is admissible depends on the age of the child. A nurse whose own infant is two to three months old will do for a child of six to eight months, but for a three-months child the first milk is often insufficient.

[2] See Baumm and Illner (*loc. cit.*), on whose careful observations and analyses most of the above statements are based.

3. *Influence of the Mother's Diet on the Composition of her Milk.*—Careful observations on this important subject were made by the authors already quoted (Baumm and Illner). They fed various nursing women on the following diets, and analyzed the milk produced on them :

1. An ordinary mixed diet taken in great abundance.
2. A highly nitrogenous diet—*i.e.*, one containing much cheese, eggs and meat.
3. A diet rich in carbohydrates and fat, but poor in nitrogen—*i.e.*, plenty of bread, farinaceous foods, sugar and butter.
4. A very fluid diet.
5. An ordinary diet plus 2 to 3 pints of lager beer daily.
6. A diet consisting largely of salt fish, pickles, and other salt foods.

They found that, on the whole, fat was the only ingredient of the milk on which the diet produced any appreciable effect. It was increased, sometimes rising 1 per cent., on the first and second diets only. An abundant supply of carbohydrates had no influence upon the amount of fat. Nor, curiously enough, had the amount of fat consumed in the food; indeed, an increased amount of fat eaten seems to diminish rather than increase the amount of cream in the milk. These results are in harmony with those obtained in the feeding of cows, where a bean diet produces more and richer milk than any other, and the amount of fat in the food is without effect.[1] It is surprising, too, that an increased amount of fluid in the diet does not appreciably increase the total yield of milk. Nor did the diet of salted foods affect the composition of the milk or the health of the child.

On the whole, the results of these and of similar experiments[2] tend to show that the composition of the milk yielded is to a large extent independent of the diet, just as we have seen it to be of other external conditions. Even if the supply of food is to a large extent cut off, the mother goes on producing milk just as before, only at the expense of her own tissues. Thus, it was found that during the siege of Paris women were able to continue nursing although almost starved to death. The influence of alcohol on the secretion and composition of milk is a subject of great practical importance.[3] The experiments just quoted showed that 2 to 3 pints of light

[1] Thomson, 'Food of Animals,' p. 132; London, 1846.

[2] See Cautley, 'Feeding of Infants,' pp. 92-96.

[3] For an elaborate résumé of our knowledge on this subject, see Rosemann, *Archiv. f. die Ges. Physiolog.*, lxxviii. 466, 1900.

beer daily had no effect on the composition of the milk, and other observers have shown that as much as five glasses of port or champagne are similarly devoid of influence.[1] Physiologically alcohol may be regarded as the nutritive equivalent of a certain amount of fat (p. 329), and as fat in the diet is without favourable influence on the composition of the milk, so, too, is alcohol. The common prescription of stout for nursing mothers is thus devoid of scientific justification, for the nutritive ingredients of stout are its alcohol and a certain proportion of sugar, and both of these are unable to improve the quality of the milk.

On the other hand, the bad effects on the child, which have been attributed to the taking of alcohol by the mother, are equally imaginary, the fear that alcohol will be excreted by the milk being groundless, unless, indeed, the mother indulge in it to the extent of producing intoxication. Distillation of the milk in the above experiments failed to show the presence of any alcohol in it at all.

Alcoholic liquors, then, cannot directly affect the quality of the milk. On the other hand, if a little bitter beer or a glass of wine at meals increases the mother's appetite and her power of digesting ordinary food, then such an addition to her diet will improve her own nutrition and with it the composition of her milk.

Seeing that the composition of the milk is so little affected by diet, one need not jump to the conclusion that if a suckling is suffering from dyspepsia there is some error in the mother's food. So long as the proportion of fat in the milk remains normal, it may be assumed that there is no great fault in the dietary of the mother. On the other hand, if the milk shows a deficiency of fat, the best way to improve its quality is to increase the appetite of the mother for ordinary food, to supply her with that abundantly, and of an easily-digested quality, to let her have four meals daily, and to see that meat or some other form of proteid food is well represented in at least three of them.

4. *Influence of Frequency of Suckling on the Composition of the Milk.*—The act of suckling serves as a stimulus to the breast, and if repeated at too short intervals the richness of the milk is increased, and it may become less digestible. Hence, if a child is crying from indigestion, an attempt to quieten it by frequently giving it the breast is sure to lead in the end to the production of an even less digestible milk, and so to an aggravation of the trouble.

[1] Klingemann, quoted by Cautley.

3. Amount of Milk required by the Child daily.

One can only arrive indirectly at the amount of milk which a child should get at each meal and in the course of the day. Arguments from the size of the stomach in infancy are not of much value, for individual variations in the size of the stomach are very wide, and the size after death is no certain criterion of the capacity during life. Nor is the amount of milk in the breast a certain guide, for the child need not exhaust the breast at each meal. A method which has been widely adopted is that of carefully weighing the child before and after each feed. If carried out on a sufficiently large number of infants, this method affords a fairly reliable basis from which to arrive at the average quantities required at each age, and it is by such a method that the following tables have been constructed.

AMOUNT OF MILK REQUIRED DAILY (CAMERER).

Period.	*Quantity in Twenty-four Hours.*
1st day	30 grammes.
2nd ,,	130 ,,
3rd ,,	240 ,,
4th ,,	290 ,,
5th ,,	330 ,,
6th ,,	365 ,,
7th ,,	400 ,,
Middle of 2nd week	450 ,,
End ,, ,,	500 ,,
3rd week	497 ,,
4th ,,	582 ,,
5th ,,	653 ,,
6th ,,	734 ,,
7th ,,	780 ,,
8th ,,	803 ,,
9th ,,	817 ,,
10th ,,	850 ,,
11th ,,	764 ,,
12th ,,	767 ,,
13th ,,	819 ,,
14th ,,	829 ,,
15th ,,	838 ,,
16th ,,	843 ,,
17th ,,	851 ,,
18th ,,	875 ,,
19th ,,	872 ,,
20th ,,	820 ,,
21st ,,	862 ,,
22nd ,,	848 ,,

AMOUNT OF MILK REQUIRED DAILY—AVERAGE MEALS (FEER).[1]

Period.	*Quantity.*	*Per Day.*
1st week	40 to 50 grammes.	291 grammes.
2nd ,,	80 ,, 90 ,,	549 ,,
3rd to 4th week	85 ,, 110 ,,	590 to 652 ,,
5th ,, 8th ,,	120 ,, 135 ,,	687 ,, 804 ,,
9th ,, 12th ,,	140 ,,	815 ,, 828 ,,
13th ,, 16th ,,	150 ,,	852 ,, 893 ,,
17th ,, 20th ,,	155 ,,	902 ,, 947 ,,
21st ,, 24th ,,	160 ,,	956 ,, 980 ,,

Obviously these data must only be regarded as affording average indications. They must not be applied too absolutely to any given child, for small and weakly children will necessarily require less nutriment than those which are heavy and strong, and healthy infants of a few weeks may take as much milk as feebler ones whose age is counted by months.

Bearing these precautions in mind, then, one may say that on an average a healthy infant will require—

During 1st to 4th week	600 grammes milk daily.
,, 2nd ,, 4th month	800 ,, ,,
,, 5th ,, 7th ,, ...	950 ,, ,,

The child will require eight meals in the twenty-four hours; therefore a wet-nurse should yield from each breast two or three hours after the last suckling—

In 1st to 4th week	40 grammes.
,, 2nd ,, 4th month	55 ,,
,, 5th ,, 7th	65 ,,

The importance of **regularity in the feeding** of infants cannot be exaggerated. By proper timing of the meals it can be arranged that the stomach shall have plenty of time to empty itself, and thus one cause of indigestion will be avoided. The child is a creature of habit, and if it be trained to regular feeding hours will not expect feeds between meals. The following table, borrowed from Holt, represents in a convenient form the best intervals for feeding at different ages, and (approximately) the amount of drink to be taken at each meal. The table is constructed in order to afford guidance as to the quantities to be given in artificial feeding, but the same time intervals should be observed when the child is being fed by the breast, although in that case the quantity taken can usually be safely left to be determined by the appetite of the child.

[1] Quoted by Hauser, *Fortschr. der Med.*, Bd. 15, No. 24, 1897.

SCHEDULE FOR FEEDING HEALTHY INFANTS DURING THE FIRST YEAR.

Age.	Number of Feedings, Twenty-four Hours.	Interval between Meals by Day.	Night Feedings (10 p.m. to 7 a.m.).	Quantity for One Feeding.		Quantity for Twenty-four Hours.	
		Hours.		Ounces.	Grammes.	Ounces.	Grammes.
3rd to 7th day	10	2	2	1-1½	30-45	10-15	310-460
2nd and 3rd weeks ..	10	2	2	1½-3	45-90	15-30	460-930
4th and 5th weeks ..	9	2	1	2½-3½	75-110	22-32	680-990
6th week to 3rd month ..	8	2½	1	3-4½	90-140	24-36	740-1,110
3rd to 5th month	7	3	1	4-5½	125-170	28-38	870-1,080
5th to 9th month	6	3	0	5½-7	170-220	33-42	1,020-1,300
9th to 12th month ..	5	3½	0	7½-9	235-280	37-45	1,150-1,400

As in the previous tables, the *quantities* in this case must again be regarded as only applicable to the healthy child of average weight, and may require to be reduced somewhat for delicate infants. There are two criteria by which one can judge whether the amount given is sufficient: (1) the weight of the child, (2) the character of the stools. Regular weighing is of the greatest importance, and if a steady increase in weight is not manifest, there is something wrong with the diet. Inspection of the stools will show whether they contain any undigested milk, and so whether absence of increase in weight is due to deficiency in the amount of the diet or to some defect in its quality.

4. Digestibility of Human Milk.

Stomach digestion is not of much importance in infancy. The stomach in early life is small in capacity and of but feeble muscular power, and seems to allow the food introduced into it to pass quickly on into the intestine, where the essential work of digestion takes place. Thus, it has been found,[1] by washing out the stomachs of infants at varying intervals after feeding, that, if 3 ounces of milk be taken at a meal, fully three-fourths of it has left the stomach after the lapse of two hours, and that in another twenty or thirty minutes the stomach is entirely empty.

[1] Van Puteren (Diss. St. Petersburg, 1889), reference in *Jahrb. f. Kinderheilk.*, xxxi. 188, 1890.

Whether the milk really clots in the stomach in very early life is disputed, some writers contending that there is no rennet to be found in the stomach during the first month. Whether this be so or not is not of much importance, for the clot formed by human milk is, for reasons to be explained later (p. 433), very much looser than the clot formed by cow's milk, and does not offer any serious difficulty to the stomach in its digestion.

The **absorption of the constituents of human milk** in the intestine of infants seems to be very complete. Proteid is said[1] to be absorbed to the extent of 99 per cent., fat to 97 per cent., and the mineral salts to 90 per cent., while the sugar enters the blood in its entirety. During the first week or so of life, however, the absorption of the fat of the milk does not seem to be always as perfect as these figures would indicate, and a good deal of fat may be found in the motions.[2] It would seem, indeed, as if the newly born infant required a little practice before it is able thoroughly to digest even its mother's milk.

5. Nutritive Value of Human Milk.

Comparing the nutritive value of a given amount of human milk with that of an equal quantity of cow's milk, one may say that the two yield practically the same amount of solid nutriment; but the fuel value of the cow's milk is rather greater than that of human milk, owing to the larger amount of fat which it contains. The difference, however, is not great, for 100 grammes of cow's milk yield 66 Calories, and a similar quantity of human milk 62½ Calories. Both in building material and in fuel value, therefore, human milk is a poorer fluid than the milk of the cow.[3]

An ordinary infant, six months of age, consuming the usual amount of breast-milk, will get from it, roughly speaking, the following amounts of nutritive materials:

Proteid	14 grammes.
Fat	30 ,,
Carbohydrates	59 ,,

Similar quantities would be contained in a daily diet of 2½ ounces of beef (half an ordinary plateful), 1 ounce of butter (the quantity

[1] Uffelmann, *Deut. Archiv. f. Klin. Med.*, xxviii. 437, 1881.

[2] See Blauberg, 'Studien über Säuglingsfaces,' Berlin, 1897.

[3] The direct observations of Rubner show that 1 litre of human milk yielded in one instance 614·2 Calories, and in another 723·9. A similar quantity of cow's milk yields 690·4. In other words, an average sample of either human or cow's milk may be expected to yield close on 700 Calories per litre. Under the most favourable conditions in the adult, only 90 per cent. of this is available, owing to defective absorption, whereas in the infant, in which the digestion of milk is more perfect, 91 to 91·6 per cent. is available.

usually used to spread four slices of bread), and 2 ounces of sugar (equal to 3¾ level tablespoonfuls). One may compare these quantities with the standard for an ordinary man doing moderate work thus:

	Adult at Moderate Work (Voit). (Weight = 70 Kilos.)	*Infant of Six Months. (Weight = 6·7 Kilos.)*
Proteid	118	14
Fat	56	30
Carbohydrate ..	500	59
Calories	3,054	578

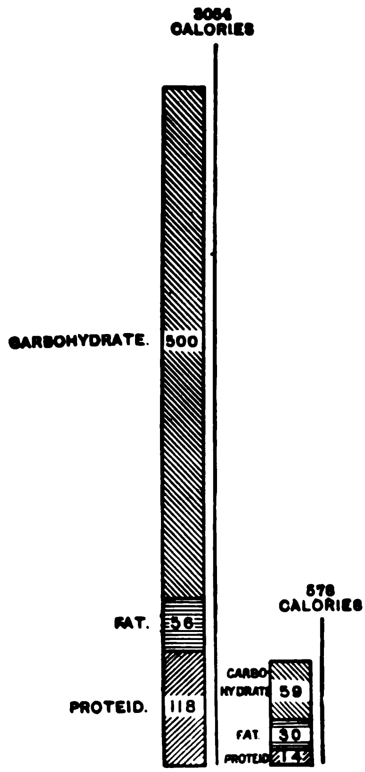

FIG. 34.—COMPARISON OF NUTRITIVE CONSTITUENTS REQUIRED BY AN ADULT AND BY AN INFANT OF SIX MONTHS.

The comparison is also exhibited in a graphic form in Fig. 34. One is at once struck by the relatively large amount of fat which the diet of human milk contains. The infant of six months actually obtains more than half as much of that constituent as the full-grown man. The relation of proteid to carbohydrate in the two

diets is very similar, but one must remember that the man is doing muscular work, while the infant is not. Relatively to weight and mode of life, therefore, the infant is much more abundantly nourished than the man.[1]

One sees, too, that a nursing mother yields up about one-eighth of the proteid and carbohydrate in her diet to her child, and fully one-half of the fat, whilst more than one-fifth of the fuel value of her food is also handed over to the infant. The chemical energy which a mother expends daily, therefore, in nursing an infant six months of age would be sufficient to raise a ton weight about 800 feet high, or more than twice as high as the top of the dome of St. Paul's.[2]

[1] The surface of the child is relatively three times as great as that of the adult. The following table (from Camerer) shows the relation between extent of surface and the Calories supplied in the diet at different periods of life:

Infants.

Age in weeks	2	7	14	20	59
Weight in kilos.	3	4·2	5·3	6·3	10·3
Calories per square metre of surface	1,020	1,420	1,330	1,270	1,390

Boys.

Age in years	3 to 5	7 to 10	11 to 14	15 to 16
Weight in kilos.	18	24	34	52 ,, 58
Calories per square metre of surface	1,680	1,440	1,250	1,220

Adults.

Weight	65·5 kilos.
Calories (rest)	1,190
,, (work)	1,420

Immediately after birth, therefore, a child gets a smaller supply of Calories per square metre than an adult, and consequently loses in weight, but later on it gets more per surface area, and is thus able to grow.

[2] This, of course, is assuming that the whole potential energy of the milk could be converted into work.

CHAPTER XXV

THE PRINCIPLES OF FEEDING IN INFANCY AND CHILDHOOD (*continued*): SUBSTITUTES FOR HUMAN MILK

In the last chapter we learnt that the physiological peculiarities of infancy demand that the diet during that period of life should be relatively rich in proteid and mineral matter, and especially so in fat. A consideration of the chemical composition of human milk showed how well adapted it is to meet these demands, while a computation of the amount of it which infants consume at different ages enabled us to form some idea of the quantity of each nutritive ingredient actually required at each period of infancy. Further investigation taught us that human milk is easily disposed of by the infant's stomach, is absorbed very completely in the intestine, and is a fluid of high nutritive value, and therefore eminently adapted for the requirements of the child.

These results of scientific investigation have been long anticipated by experience, and both unite to emphasize the inestimable value to the infant during the first ten months at least of its life of a dietary of human milk. Unfortunately, however, the mother is often unable or unwilling to suckle her infant, and one has to find some substitute for the natural supply. A wet-nurse is, of course, from the infant's point of view, the best alternative, but one need hardly say that this mode of feeding is open to considerable practical disadvantages. One naturally looks next to **the milk of other animals**. The following table exhibits the approximate composition of the milk of some of the commoner domestic animals compared with that of human milk :

COMPOSITION OF THE MILK OF DIFFERENT ANIMALS.[1]

	100 Grammes Milk contain in Grammes				
	Proteid.	*Fat.*	*Sugar.*	*Ash.*	*Other Nitrogenous and Unknown Bodies.*
Human	0·9	3·52	6·75	0·19	0·6
Cow	3·0	3·55	4·51	0·70	0·3
Goat	2·8	3·40	3·80	0·95	—
Mare	1·9	1·00	6·33	0·45	0·49
Ass	1·6	0·93	5·60	0·36	—

It will be observed that none of these is identical with human milk.

This is not surprising, for the composition of a milk, especially as regards its proteids and mineral constituents, seems to depend upon the rate of growth of the animal for which it is intended. The faster a young animal grows, the richer is the mother's milk in these two ingredients. This fact is brought out very strikingly in the following table :[2]

	Time by which Weight is Doubled.	100 Parts Milk contain			
		Proteid.	*Ash.*	*Lime.*	*Phosphoric Acid.*
Human ..	180 days	1·0	0·2	0·032	0·047
Horse ..	60 ,,	2·0	0·4	0·124	0·131
Calf	47 ,,	3·5	0·7	0·160	0·197
Goat	19 ,,	4·3	0·8	0·210	0·322
Pig	18 ,,	5·9	—	—	—
Sheep ..	10 ,,	6·5	0·9	0·272	0·412
Cat	9½ ,,	7·0	1·0	—	—
Dog	8 ,,	7·3	1·3	0·453	0·493
Rabbit ..	7 ,,	10·4	2·4	0·891	0·996

The **milk of the ass** has often been stated to be the closest approximation to mother's milk. I have collected the results of all the most recent analyses of it, and compared them with the standard of composition of human milk as follows :

	Ass's Milk (Schlossmann's Analysis).[3]	*Average of other Analyses.*[4]	*Human Milk.*[5]
Water	88·80	90·5	87·60
Proteid	1·30	1·9	1·52
Fat	0·36	1·4	3·28
Sugar	4·94	6·3	6·50
Mineral matter ..	0·309	0·4	0·27

It will be observed that ass's milk is poorer in every ingredient except, perhaps, proteid and mineral matter. It is especially poor in fat, which is so important to the infant. In addition to this it is

[1] Heubner, 'Ueber Milch und Milchpräparate,' *Zeit. f. Diät und Physik. Therapie,*' Bd. 3, p. 1, 1899.
[2] Heubner, *Zeit. f. Diät und Physik. Therapie*, Bd. 3, p. 1, 1899.
[3] Schlossmann, *Zeit. f. Physiol. Chem.*, Bd. 23, p. 258, 1897.
[4] Dujardin Beaumetz, Wynter Blyth, Peligot, Cheadle.
[5] Camerer and Söldner, *loc. cit.*

stated to be slightly laxative in its effects, and contains relatively more casein and less albumin than human milk. It is expensive also, and difficult to obtain, although one at least of the large London dairy companies now keeps a stock of milch asses for the purpose of supplying it. On the whole, it cannot be said to be in any way superior to the modifications of cow's milk of which I shall shortly speak.[1]

The same remarks are applicable to **mare's milk** as to ass's, except that the former is richer in sugar. **Goat's milk** is a strong milk, stronger even than cow's, and in no way suited for use in infancy.

In the vast majority of cases, then, cow's milk must be the substitute, and hence a careful study of the differences, chemical and physiological, between it and human milk is a matter of the first importance.

Chemical Differences between Human and Cow's Milk.

(*a*) *Quantitative Differences.*—Taking the average results of a great number of observations on the general chemical composition of the two milks, one may compare them thus:

	Human Milk.	*Cow's Milk.*
Water	87 to 88 per cent.	87 to 88 per cent.
Proteid	1 ,, 2 ,,	2 ,, 3 ,,
Fat	3 ,, 4 ,,	3½ ,, 4½ ,,
Sugar	6 ,, 7 ,,	4 ,, 5 ,,
Mineral matter ..	0·1 ,, 0·2 ,,	0·7 ,,
Reaction	Alkaline.	Acid.

One sees that while the total amount of solids in the two kinds of milk is about the same, yet the relative proportions of the different constituents in the two cases are very different. Cow's milk is the richer in proteid, mineral matter, and (to a less degree) in fat; human milk excels in sugar. The superiority of cow's milk in the building materials is no doubt due to the more rapid rate of growth

[1] Since the above was written an elaborate examination of ass's milk has been published by Ellenberger. He gives the following summary of his analyses:

	Proteid.	*Fat.*	*Sugar.*	*Ash.*
During pregnancy	1 to 1·5	1	6	0·4
Colostrum (second day) ..	2·5	1·15	6	0·65
Between pregnancies.. ..	1·2 to 1·7	0·1 to 1·7	5 to 6	0·3 to 0·4

He states that ass's milk is always alkaline in reaction, usually clots on boiling, and behaves to acids and rennet like human milk. It resembles the latter also in leaving no residue of nuclein or paranuclein on digestion. Its chief chemical characteristic is its poverty in fat; the proportion of proteid is very much the same as in human milk. The ratio of albumin to casein is rather high. Further, it has the advantage that asses very rarely suffer from tuberculosis, but the percentage of fat is much too low to make it suitable for habitual use by children.

of the calf than of the infant, but the excess of carbohydrate in human milk is rather surprising when one compares the relative muscular activities of the calf and the baby. It suggests that some of the sugar in human milk is intended as a weak form of fuel instead of the more powerful heat-producing fat, and this substitution may be due to human milk having been devised as an infant food suited to a warmer climate than that which civilized man now occupies.

(*b*) *Qualitative Differences.*—On more closely examining cow's milk, one finds that the differences in *kind* between its principal ingredients and those of human milk are even greater than the differences in their relative amounts. Sugar, indeed, is the only ingredient which is identical in kind in the two milks; the nitrogenous matters, the fat and the mineral salts must be compared separately in each.

1. **Nitrogenous Matters.**—We have already seen that human milk includes a considerable proportion of unknown 'extractive' bodies which contain nitrogen. Cow's milk contains considerably less of these. One-eleventh of the total nitrogen in human milk is present in the form of extractives, as compared with one-sixteenth in cow's milk.[1] As to the uses of these extractives to the child we are entirely in the dark, but it is conceivable that too low a proportion of them in the diet may not be free from disadvantages.

The proteids of milk are of two kinds, casein and albumin (Chapter VII.). Cow's milk contains relatively much more of the former, and human milk of the latter. The exact proportions given by different analysts vary considerably, but a reliable estimate has given six parts of casein to one of albumin in cow's milk, and the proportions of the two in human milk as equal.[2] When one remembers that albumin is a much more easily digested form of proteid than casein, it is evident that there is here an important practical difference between the two milks. Not only so: the casein itself is actually different in the two forms of milk. Cow's casein leaves behind an indigestible residue (paranuclein); human casein does not.[3] When an acid is added to cow's milk the casein is thrown down in large flocculi, which do not readily dissolve in excess; under similar treatment human milk yields very fine flocculi which readily go into solution on adding more acid. Lastly,

[1] See Munk, *Virchow's Archiv.*, cxxxiv. 501, 1893, and Camerer and Söldner, *Zeit. f. Biol.*, 535, 1896.
[2] Hammarsten, *Jahres-Ber. f. Thierchemie*, p. 206, 1895.
[3] Szontagh, *Ungar. Archiv. f. Med.*, 1894 (reference in *Jahres-Ber. f. Thierchemie*, p. 209, 1894).

human casein is richer in sulphur than the casein of cow's milk. For these reasons human casein is more easily digested.

2. **Fat.**—The fat of human milk contains more oleic acid, and has consequently a lower melting-point and is more easily digested than the fat in cow's milk. This greater digestibility of the fat of human milk is increased by the fact that it is present in a much finer state of division than the fat droplets in cow's milk. Human milk fat contains also much less of the soluble or volatile fatty acids than one finds in the fat of cow's milk[1]; the exact significance of this is, however, unknown.

3. The **mineral salts** in the two forms of milk also show important differences. Not only are calcium and phosphorus both present in much smaller amount in human milk, but there are important differences in the form in which the phosphorus occurs in the two cases. In human milk there is only, or almost only, organically combined phosphorus present; in cow's milk less than half is in this form of combination.[2] In its high proportion of organic phosphorus human milk recalls the chemical peculiarities of plant embryos or the yolk of egg. Considering the great importance of phosphorus in the nutrition of the infant, and the fact that organic combinations of it are probably more easily assimilated than its inorganic salts, one must admit that the differences between human and cow's milk just pointed out are not to be lightly disregarded.

In the light of these facts, regarding the profound qualitative differences in chemical composition between human and cow's milk, one must conclude that it is impossible ever so to modify the latter that it shall be identical with the former. In other words, *a truly 'humanized' cow's milk is a chemical impossibility.*

Comparative Digestibility of Cow's and Human Milk.

It is a familiar fact that most young infants have much greater difficulty in digesting cow's milk than that of their own mother. The chief reason for this is that cow's milk forms a much denser clot in the stomach than human milk.

[1] Laves, *Zeit. f. Physiol. Chem.*, xix. 369, and Ruppel, *Zeit. f. Biol.*, xxxi. 1, 1895.

[2] Of the total phosphoric acid in human milk, 35 per cent. is in the form of lecithin.

Of the total phosphoric acid in cow's milk, 5 per cent. is in the form of lecithin.

Of the total phosphoric acid in human milk, 41 per cent. is in the form of phosphocarnic acid.

Of the total phosphoric acid in cow's milk, 6 per cent. is in the form of phosphocarnic acid.

See Siegfried, *Zeit. f. Physiol. Chem.*, xxii. 575, 1896; and Stoklasa, *ibid.*, xxiii. 343, 1897.

The greater **density of the clot** is due—(1) to the absolutely larger proportion of casein in cow's milk, and probably also to those chemical differences between cow's and human casein already mentioned; (2) to the smaller proportion of fat and soluble albumin relative to the casein which characterizes cow's milk—the soluble albumin and fat of human milk seem to act mechanically in producing a loose clot; (3) to the fact that cow's milk contains six times as much calcium and three times as much acid as human milk, and the density of the clot depends very much, as was explained in Chapter VII., on the proportions of these two constituents.

For all these reasons cow's milk tends to form a dense, retracted clot in the stomach, while the clot of human milk is loose, friable, and easily broken up.

In the intestine there is much less difference in behaviour between the two milks. The stools of infants fed on cow's milk are richer in mineral matters than those of breast-fed children, but, then, so is the milk on which the latter are fed. A higher proportion of the fat of cow's milk also escapes digestion than is the case with human milk, and probably also a somewhat greater proportion of p oteid;[1] certainly the fæces of bottle babies contain more nitrogen than those of infants reared at the breast.

Infant Feeding with Cow's Milk.

Notwithstanding the pronounced differences in chemical composition and physiological behaviour between cow's and human milk, there are some healthy infants who can be reared on the former without modification.[2] Obviously they will require smaller feeds of the cow's milk; indeed, about 2 ounces at each feed is found to suffice. In most cases, however, and certainly in all feeble infants, pure cow's milk will be found to be difficult of digestion, and requires some modification to render it suited to the digestive powers of the infant.

From what has been already said, it is evident that such modification can only affect the quantities of the different ingredients in the milk; the distinctive peculiarities of the ingredients as opposed to those of human milk will still remain. By suitable treatment, however, the proportion of casein, calcium, and acid salts present

[1] See Blauberg, 'Studien über Sänglingsfäces,' pp. 107, 108; Berlin, 1897.

[2] Budin, *Bull de l'Acad. de Méd.*, 1893 and 1894. For a summary of the results yielded by Budin's method and a criticism of it, see Marfan, 'Traité de l'Allaitement,' p. 313; Paris, 1899.

can be reduced, and the digestibility of the milk proportionately raised. We must now briefly consider the different methods by which this can be done.

1. The simplest method is **by mere dilution**. The problem here is to reduce the casein and mineral matters in the cow's milk, to leave the proportion of fat much as it was, and at the same time to increase the amount of sugar. Taking the average composition of cow's and human milk, and adding 1 part of water to 2 parts of the cow's milk, we get the following comparative results :

	Human Milk.	*Cow's Milk.*	*Cow's Milk 2 parts. Water 1 part.*
Proteid	1·5	2·5	1·6
Fat	3·5	4·0	2·6
Sugar	6·5	4·5	3·0
Mineral matter ..	0·2	0·7	0·4

This makes the proportion of proteid about right, but leaves the fat 1 per cent., and the sugar 3½ per cent., too low. If now one adds to every 8 ounces of the mixture 2 ordinary sized teaspoonfuls of milk-sugar[1] pressed flat and ½ ounce of cream (containing 15 per cent. of fat), these defects are rectified, and, except for a slight excess of mineral matter, the mixture will have approximately the same proportion of each ingredient as human milk. The digestibility of such a mixture is still, however, inferior to that of milk from the breast, for water in this proportion does not prevent the formation of a rather dense clot in the stomach. For this reason it is better to dilute with lime-water rather than with plain water, for, as we have already seen in a previous chapter, lime-water possesses a specific power of preventing the clotting of milk, even in the proportion of one-third of the whole mixture.[2] Barley-water has also been long in use for the same purpose, though its value has been disputed by some writers. Whilst I regard it as much inferior in its power of preventing clotting to an equal quantity of lime-water, I hold, as the results of my own experiments, with those who regard it as leading to the formation of a looser and more digestible clot than ordinary water is capable of doing.

In the case of very young or weakly infants, it may be necessary to dilute the milk more freely than in the proportion given above. In such a case a mixture of equal parts of milk, water, and lime-water is to be recommended, cream and sugar being added as before. Although this is chemically weaker than human milk, many infants

[1] White cane-sugar will also do, but milk-sugar is better.

[2] Lime-water has the additional advantage of reducing the total acidity of cow s milk, which is three times greater than that of breast-milk.

thrive upon it well enough. One may then give 2 parts of milk to 1 of water and 1 of lime-water, and finally arrive at the stage in which the water is left out altogether, as first described.

2. More elaborate methods are the **cream mixtures** of Meigs, Rotch, and Biedert.

Meigs[1] allows a quart of milk to stand for three hours in a cool place in a tall vessel. At the end of that time he carefully decants the upper half of the milk, which is now rich in cream. To every 1½ ounces of this he adds 1 ounce of lime-water and 1½ ounces of sugar-water, which is made by dissolving 8 heaped teaspoonfuls of milk-sugar in 16 ounces of water. This mixture will obviously be poorer in proteid than that described above.

Rotch's formula[2] is very similar. He takes

Cream (20 per cent. fat)	1½ ounces.
Milk	1 ounce.
Water	5 ounces.
Milk-sugar	3⅜ drachms.

The mixture is boiled, and when cool ½ ounce of lime-water is added. It is stated to have the following composition:

Proteid	1·2
Fat	4·2
Sugar	6·5

It is rather too rich in fat for general use.

Biedert[3] uses a mixture of 130 c.c. of cream (10 per cent. fat) with 390 of water and 18 grammes of milk-sugar. This results in a milk containing 1 per cent. of casein, 2½ per cent. of fat, and 5 per cent. of sugar. For very young infants the mixture may require to be given more diluted.

3. *Soxhlet*[4] dilutes the milk with half its volume of a 12½ per cent. **solution of milk-sugar**. This makes the proportion of proteid the same as in human milk, but leaves the fat one-third less and the sugar one-half more. In other words, some of the fat by this method is replaced by sugar. Considering the great importance of fat in the infant economy, it is doubtful if such a substitution is justifiable. Heubner,[5] however, reports that he has fed thousands of the most miserable infants on the mixture with the greatest success. It certainly has the merit of simplicity.

[1] 'Archives of Pediatrics,' p. 833, 1889, and 'Milk Analysis and Infant Feeding,' p. 74; Philadelphia, 1885.
[2] Described by Cautley, 'Infant Feeding,' p. 150.
[3] See Reinach, *Münch. Med. Woch.*, No. 29, 1899.
[4] *Münch. Med. Woch.*, No. 4, 1893.
[5] Heub ner, *Berlin. Klin. Woch.*, No. 3 , 17.

4. So-called **humanized milks** are now prepared on a large scale by many dairy companies. By diluting the milk with an equal quantity of water and subjecting it to the action of a centrifuge, it is divided into two equal parts, one of which contains practically all the fat o the original milk but only half of the other ingredients. Thef deficiency of sugar is remedied by the subsequent addition of that constituent in the necessary proportion. The proportion of proteid in such a milk will tend to be somewhat too low, and the mineral matter still too high, but otherwise the composition will correspond pretty closely to that of human milk.

The following analyses of their humanized milks are supplied by the Aylesbury Dairy Company:

	No. 1.	*No. 2.*	*Human Milk.*
Water	89·43	88·3	87·6
Proteid	1·3	2·2	1·5
Fat	4·0	3·6	3·5
Sugar	4·7	5·2	6·5
Mineral matter ..	0·49	0·57	0·27

Both milks tend to be too rich in fat and too poor in sugar. The first contains too little proteid, and the second rather much. No. 1 is intended for young and delicate infants, No. 2 for those which are older and stronger. We saw, however, that human milk does *not* tend to get richer in proteid as lactation proceeds, and for that reason the preparation of a stronger milk for older infants is not physiologically sound.

Paget's Perfected Milk Food[1] is a concentrated humanized milk. When diluted with 2 parts of water it yields a fluid of the following composition:

Water	88·04
Proteid	1·08
Fat	3·83
Sugar	6·82
Mineral matter	0·23

It is sterile and keeps indefinitely. My own examination of it shows that it is certainly rich in fat, and hardly clots at all with rennet. It is, perhaps, somewhat deficient in proteid.

Gaertner's Fettmilch[2] is another commercial humanized milk prepared on the above principles. It is stated to have the following proportions of the chief ingredients:

Proteid	1·5 per cent.
Fat	3·2 ,,
Sugar	6·0 ,,
Mineral matter	0·35 ,,

[1] Clay, Paget, and Co., Limited, 20, Bentinck Street, W.
[2] Sold by the Friern Manor Dairy Company.

With the exception of a somewhat higher proportion of mineral constituents (a point of no importance), these figures are almost identical with those yielded by an average sample of human milk. Very good results from its use have been reported by several observers,[1] although others have put on record cases in which it has disagreed.[2]

One defect common to all the above methods must be pointed out. It is truethat they bring the total amount of proteid down more or less equal to that found in human milk. They do not, however, influence in any way the relative proportion of the two proteids of milk—casein and albumin. In all of them the former remains relatively higher than in human milk, and the latter relatively lower. For this reason the resulting mixtures must remain more difficult of digestion than human milk is. Various methods of getting over this difficulty have been proposed.

Hammarsten[3] takes advantage of the fact that whey contains the albumin of the milk but not its casein (see p. 128), and by making a mixture in the following proportions:

Cream	200 parts,
Whey	800 ,,

or

Cream	100 parts,
Milk	100 ,,
Whey	800 ,,

he gets a fluid which contains albumin and casein in the same proportion as in human milk.

Ashby[4] is also a strong believer in the virtues of whey. He prepares it by placing 30 ounces of fresh milk in a Hawksley's sterilizer and heating to 104° F.; two teaspoonfuls of Benger's essence of rennet are added, and the bottle set aside for a few minutes. When curdling has taken place the curd is thoroughly broken up by stirring and shaking, and the whey is then strained off through fine muslin. In this way 22 or 23 ounces of opalescent whey are obtained. This is heated to 180° for twenty minutes to destroy the rennin, and is then strained again. The composition of the whey so obtained is as follows:

Proteids	0·97
Fat	2·0
Salts	0·61

[1] See Gaertner, *Wiener Med. Woch.*, No. 23, 1896; Fischer and Poole, *New York Medical Record*, December 11, 1897; and Schütz, *Wiener Klin. Woch.*, No. 48, 1896 (experiments on adults).

[2] Hauser's résumé, *Fortsch. d. Med.*, Bd. 15, No. 24, 1897. See also Monti, *Wiener Klinik*, 1897, Hft. 1, 2, and 3; and the *Year-Book of Treatment*, p. 159, 1897.

[3] *Jahres-Ber. f. Thierchemie*, p. 206, 1895.

[4] *Edinburgh Medical Journal*, April, 1899.

The whey may be used alone with the sole addition of 2 or 3 drachms of milk-sugar to the pint as a food for newly-born infants. A weak 'humanized' milk may be prepared by mixing 10 ounces of fresh milk with 20 of whey and adding ½ ounce of milk-sugar. It has the following composition:

Proteids	1·75
Fat	2·5
Sugar	6·0
Salts	0·6

If a milk richer in fat is desired, 'top' milk should be used in the same proportion. To prepare it, let a quart of fresh milk stand in a covered jar in a cold place for four or five hours, remove the upper 10 ounces by skimming, and add to this 20 ounces of sterilized whey and ½ ounce of milk-sugar. The mixture should contain 4 per cent. of fat. A grain or two of bicarbonate of soda may be added to the mixtures to render them alkaline.

Monti[1] also recommends the use of whey. For the first three months he employs a mixture of equal parts of milk and whey, after that a mixture of two of milk to one of whey.

Vigier[2] divides the milk into two equal parts. He skims one and adds the cream to the other. The former is then clotted with rennet, and the whey added to the other half. The resulting mixture has the following composition:

Proteids	2·36
Sugar	4·10
Fat	3·75
Salts	0·75

Winter[3] goes on a similar plan when he divides the milk into two parts, skims one, and adds the cream to the other. He then coagulates the skimmed portion with rennet, and adds the whey which he obtains to the first part. Such a mixture contains the casein and albumin in proper proportions, but is still apt to be deficient in fat.

The advantage of whey as a diluent is that it is antiscorbutic, and contains albumin and a little fat. It must be admitted, however, that the preparation of the above mixtures demands more time and trouble on the part of the mother or nurse than one can usually count on.

Lehmann[4] dilutes the milk till the casein is in proper proportion, and then adds sugar and cream. In order to bring up the proportion

[1] *Wiener Klinik*, 1897, Hft. 1, 2, and 3.
[2] Quoted by Monti.
[3] Quoted by Rothschild, 'L'Allaitement Mixte,' etc., Paris, 1898.
[4] *Archiv. f. d. Ges. Phys.*, lvi. 558, 1894

of albumin, he takes the **white of an egg**, mixes it with four table-spoonfuls of water, and adds one-third of the mixture to the milk.

In America the modification of cow's milk to suit the requirements of infancy has been reduced to an exact science. This has been chiefly brought about by the work of Rotch. Milk containing a known proportion of casein is prepared by adding to it standard solutions of cream and milk-sugar in different proportions. A mixture can be prepared of any desired composition. Laboratories have been established[1] in all the principal towns of the United States in which, on the receipt of a physician's formula, a milk containing the exact proportion of each ingredient which the digestive peculiarities of any given infant may necessitate can be dispensed as accurately as a chemist compounds a prescription. Useful and desirable as this is in the case of badly nourished or dyspeptic babies, it is an unnecessary refinement in the artificial feeding of healthy infants.

There is still one point in which any of the above modifications of cow's milk is lacking. Human milk as it leaves the breast is practically a sterile fluid ; but this is by no means true of cow's milk as it reaches the consumer. It contains, as we have already seen (Chapter VII.), not only the organisms which cause milk to become sour, but also, and not infrequently, the germs of actual disease. These are specially dangerous to infants, because the low degree of acidity which is characteristic of the contents of the infant stomach enables these germs to pass on almost uninjured into the intestine, where they may readily become the seeds of disease. For this reason, then, the destruction of the germs in cow's milk is of the first importance in preparing it as an infant food. The methods by which this may be done have been already considered (Chapter VII.), but it may be repeated here that in most cases simple boiling is sufficient. 'Pasteurization' of the mixture at a temperature of 70° C. will almost certainly ensure the destruction of the disease germs,[2] but if the milk has to be preserved for any length of time 'sterilization' should be carried out. We have already seen that the digestibility and absorption of the milk are not interfered with by such a process to any important extent.[3]

Reviewing the whole question of the modification of cow's milk, it may be said that the first method described (boiling, with subsequent

[1] Walker, Gordon Laboratories. One of these is now open in London (Duke Street, Grosvenor Square).

[2] It has not been conclusively proved capable of destroying the tubercle bacillus.

[3] The only disadvantage attending the use of boiled or sterilized milk seems to be that it is occasionally the cause of infantile scurvy.

dilution and addition of cream and sugar) is the best and simplest method for domestic use. If, however, expense is no objection, the use of such a commercial preparation as Fettmilch is equally good and less troublesome. The correction of the relative proportions of casein and albumin, although theoretically sound, is practically not a necessity in the case of healthy infants.

When all is said and done, however, cow's milk, no matter how skilfully modified, is much inferior to human milk as a means of feeding infants, this probably depending on those qualitative differences in the composition of the two fluids which no method of modification can entirely overcome.

CHAPTER XXVI

THE PRINCIPLES OF FEEDING IN INFANCY AND CHILDHOOD (*continued*): OTHER SUBSTITUTES FOR HUMAN MILK (PEPTONIZED MILK, CONDENSED MILK, PROPRIETARY FOODS); FEEDING OF OLDER CHILDREN

1. Partially Peptonized Milk.

It is believed by some authorities that one of the essential differences between the casein of human milk and that of the milk of the cow is that the former is really a stage nearer the digested condition (*i.e.*, peptone) than the latter, and that the more easy digestibility of human casein is due to that fact. Whether this be so or not, there can be no doubt that even the partial peptonization of cow's milk renders it much more easy of digestion. Of *complete* peptonization there is no need to speak here. It is of the greatest utility as a temporary expedient in some cases of disease, or in feeble and exhausted babies, but is not really required for healthy infants. Sooner or later the stomach must be educated up to dealing with pure cow's milk, and the sooner the education is begun the better. Partial peptonization, however, may often be had recourse to with advantage as the first stage in this process of education in the case of infants whose stomachs have a greater difficulty than usual in dealing with cow's casein. It can be conveniently carried out by means of *Fairchild's Peptogenic Milk-powder*. Each of these powders contains the ferment required to digest a certain quantity of milk, along with some bicarbonate of soda, which renders the milk slightly alkaline, and enough milk-sugar to raise that ingredient to the proportion found in mother's milk.

By following the directions supplied with the powders, the process of digestion is only carried far enough partially to change the casein of the milk, enough to prevent its clotting, but not enough to absolve

the stomach from all further labour. Thus, digestion is rendered easy without the stomach being demoralized. The use of these powders is strongly recommended by Professor Chittenden.[1] He analyzed the resulting mixture, and compares it with human milk as follows:

	Human Milk.	*Milk prepared by Peptogenic Milk-powder.*
Specific gravity	1031	1032
Water	86·7	86·0
Proteid	2·0	2·09
Fat	4·1	4·38
Sugar	6·9	7·26
Mineral matter	0·2	0·26
Total solids	13·2	13·9
Reaction	Alkaline.	Alkaline.

It will be observed that the two fluids are almost identical in composition. I find, too, that milk prepared by this method does not clot with rennet, even in the presence of a considerable amount of acid.

2. Condensed Milk.

The importance of studying condensed milk will be realized when one learns that we import 500,000 cwt. of it into this country every year, and there is no commoner substitute for human milk, especially amongst the poorer classes, than this.

(*a*) *Chemical Composition.*—Condensed milk is simply cow's milk from which a large proportion of the water has been removed. The removal is effected by evaporation under reduced pressure and with the aid of a greater or less degree of heat. As a rule, the milk is only reduced to one-third of its original volume, so that in order to restore it again to the condition of the original milk all that is necessary is to add to it twice its volume of water. Unfortunately, however, the milk used for condensation is not always pure milk. Very often the cream has been removed from it by a separator, so that the product is really condensed skim milk. Cane-sugar is also frequently added to the milk after condensation, in order to aid in its preservation. As a matter of fact, all the condensed skim milks found in the market have also been sweetened, so that one may divide condensed milks into the following groups:

1. Unsweetened and condensed whole milk.
2. Sweetened and condensed whole milk.
3. Sweetened and condensed skim milk.

[1] *New York Medical Journal*, July 18, 1896.

1. Of the *unsweetened condensed whole milks* there are four examples, which have the following composition[1]:

Brand.	*Total Solids.*	*Proteid.*	*Fat.*	*Milk-sugar.*
Ideal	38·0	8·3	12·4	16·0
First Swiss ..	36·7	9·7	10·5	14·2
Viking	34·2	9·0	10·0	13·3
Hollandia	43·0	11·3	9·8	18·5

If 1 part of such a milk is diluted with 2 parts of water, the resulting fluid corresponds more or less closely to a good sample of pure cow's milk.

One disadvantage of the unsweetened milks is that they are apt to go bad when the tin has been opened. For this reason they should be kept in a cold place. It would be an advantage also if the manufacturers would put up such milk in small tins, one of which would be sufficient for a day's supply.

2. The *sweetened condensed whole milks* contain, as a rule, rather more added cane-sugar than there are solids in the milk. The following is the composition of some of the best brands; they are arranged, again, according to their richness in fat:

Brand.	*Total Solids.*	*Proteid.*	*Fat.*	*Milk-sugar.*	*Cane-sugar.*
Nestlé	77·2	9·7	13·7	15·0	37·2
Rose	76·6	8·3	12·4	17·6	36·1
Milkmaid ..	76·3	9·7	11·0	14·6	38·7
Full Weight ..	76·5	12·3	11·0	13·5	37·2
Anglo-Swiss ..	74·4	8·8	10·8	16·0	37·1

There are many other brands in the market besides these, but none of them is superior to the above.

Now, although the members of this group contain as much fat as the unsweetened condensed milks, yet so much sugar has been added that if they are mixed with only as much water as has been removed in condensation, the resulting fluid would be so sweet that one could hardly drink it. Hence, a degree of dilution is recommended on the tins of these brands which renders it impossible for the resulting fluid to be at all like cow's milk in its proportion of proteid and fat.

3. Of the *condensed separated (or skim) milks* there are an immense number in the shops. They resemble in composition the second group just described, except in that they contain almost no fat (always less than 2 per cent.). When diluted in the proportions recommended for infants, the resulting fluid is very poor in proteid and almost free from fat, and is therefore entirely unsuited for a baby's nourishment.

[1] The analyses of condensed milks in this chapter are taken from Pearmain and Moor's 'Analysis of Food and Drugs,' part i., pp. 69-78.

(*b*) *Digestibility of Condensed Milk.*—It must be admitted that condensed milk is more easily digested than fresh cow's milk. One finds that, when diluted in such proportion as to restore them to the condition of ordinary cow's milk, the condensed milks either do not clot with rennet at all or the resulting curd is much looser than in the case of pure cow's milk.[1] The presence of acid does not affect the result. The explanation of these facts probably is that the casein undergoes some chemical change in the process of condensation which renders it unfitted to form a dense clot. Certainly this greater digestibility is one point in favour of condensed milk, and justifies its occasional use for infants who are entirely unable to digest ordinary cow's milk, even when specially modified.[2]

(*c*) *Nutritive Value and Economy of Condensed Milk.*—The chief defect of condensed milks from a nutritive point of view is that they are apt to contain too little fat. The unsweetened milks are alone satisfactory in this respect. The skim milks are absolutely to be condemned on that account, and even the sweetened *whole* milks, though they contain all the fat of the original milk, yet require so great a degree of dilution, owing to the amount of sugar which they contain, that the product is notably deficient in fat. 'The following table shows the character of the liquid—it cannot be called milk—that is produced by following out the directions on the labels of half a dozen of the *best brands of* (*sweetened*) *whole-cream milk*' (Pearmain and Moor):

Sweetened Whole Milk.	*Dilution recommended for Household Purposes.*	*Fat in such Product.*	*Dilution recommended for Infants' Use.*	*Fat in such Product.*
A ..	1 to 3	2·6 per cent.	1 to 5	1·8 per cent.
B ..	1 ,, 5	1·6 ,,	1 ,, 14	0·7 ,,
C ..	1 ,, 5	1·6 ,,	1 ,, 14	0·6 ,,
D ..	1 ,, 6	1·4 ,,	1 ,, 15	0·7 ,,
E ..	1 ,, 5	2·1 ,,	1 ,, 14	0·8 ,,
F ..	1 ,, 5	1·7 ,,	1 ,, 14	0·7 ,,
G ..	1 ,, 5	1·7 ,,	1 ,, 14	0·7 ,,
Human milk ..	—	—	—	3·5 ,,

There can be no doubt that an immense amount of harm is done to infants by the indiscriminate use of such milks. Babies fed on them may look fat enough, but they are pale and flabby, and often suffer from rickets, for fatness produced by abundance of sugar in the milk is, as has been already pointed out, by no means a sure indication of health, and the pictures of such fat but flabby infants so freely spread abroad by the makers of condensed milks are very deceptive.

[1] The experiments were performed with the First Swiss brand and with Nestlé's.

[2] The great degree of dilution in which condensed milk is usually given no doubt also explains in part the ease with which babies digest it.

It comes, therefore, to this, that the only kind of condensed milk to be unreservedly recommended is that made from whole cow's milk without the addition of sugar. If one part of such a preparation is diluted with two parts of water, the product may be regarded as identical with good cow's milk, and will therefore require further dilution, sweetening, and addition of cream, just as fresh milk does (p. 434). Used in this way condensed milk is convenient in cases in which fresh milk is for any reason unobtainable, or for temporary use in the case of infants who are unable to digest the latter. There is, however, one disadvantage in its use which has yet to be mentioned. It has been found that infants fed exclusively on tinned foods are apt to suffer from a peculiar disease of the blood and bones which resembles scurvy. Infants fed on fresh milk never suffer in this way, for fresh milk contains some 'antiscorbutic' element which has not yet been identified.[1] In order to counteract the tendency to this disease, it is well to give infants which are reared on condensed milk a little orange or grape juice two or three times every week.

The question whether condensed milks are to be regarded as sterile or not is one of some importance. It seems to be by no means certain that they are, for the degree of heat to which they are subjected during condensation is not necessarily sufficient to kill all disease germs. It would be well, therefore, to boil the condensed milk after dilution and before giving it to the child.

As regards the question of **economy**, there is nothing to be said in favour of condensed milks. The cost of manufacture is bound to add considerably to that of the original milk, and, as a matter of fact, their cost is equivalent to that of cow's milk at nearly 4d. per pint.[2] In other words, the removal of two-thirds of the water from the milk has about doubled its cost.

3. Proprietary Foods for Infants.

There is an immense number of patent infant foods, almost every one of which claims to be 'the best food for infants' or 'a perfect substitute for mother's milk.' As there is a considerable degree of discrepancy in the published analyses of these preparations, I have submitted the majority of those found on the English market to a fresh examination, and the results, along with a brief description of each particular food, are contained in the following table:

[1] It is worth considering whether the citric acid in fresh milk may not be such an element. It is apt to separate out in an insoluble form in condensed milk.

[2] A tin of condensed milk contains about 290 c.c. This, diluted with 2 parts of water = 870 c.c., or about 1½ pints of cow's milk, and the original tin costs 5½d

COMPOSITION OF INFANT FOODS.

Food.	Water.	Proteid.[1]	Fat.	Carbo-hydrate.	Mineral Matter.	General Description and Remarks.
Dried Human Milk	—	**12·2**	**26·4**	**52·4**	**2·1**	**The standard of composition to which artificial substitutes should conform.**
GROUP I.						
Allenbury No. 1 .. (For children below 3 months.)	5·7	9·7	14·0	66·85	3·75	Desiccated cow's milk from which the excess of casein has been removed, and a certain proportion of soluble vegetable albumin, milk, sugar, and cream added. No starch present. ½ ounce in 3 ounces of water for a child of 3 months.
Allenbury No. 2 .. (For children of from 3 to 6 months.)	3·9	9·2	12·3	72·1	3·50	Resembles the above, but contains some malted flour in addition. No starch present. 1 ounce in 6 of water for a child of 6 months.
Horlick's Malted Milk	3·7	13·8	3·0	76·8	2·70	A mixture of desiccated milk (50 per cent.), wheat flour (26½ per cent.), barley malt (23 per cent.), and bicarbonate of soda (¾ per cent.). Contains no unaltered starch when mixed. 3 teaspoonfuls (=22 grammes) in 4 ounces of water for a child of 3 months.
Carnrick's Soluble Food	5·5	13·6	2·5	76·2	2·20	A mixture of desiccated milk (37½ per cent.), malted wheat flour (37½ per cent.), and milk-sugar (25 per cent.). When prepared according to directions, the casein is partially digested, but a considerable amount of unchanged starch is left. 1 part to be mixed with 9 of water and boiled for a few minutes.
Nestlé's Milk Food	5·5	11·0	4·8	77·4	1·30	A mixture of desiccated Swiss milk, baked wheat flour, and cane-sugar (30 per cent.). More than a third of the total amount of carbohydrate is in the form of starch. 1 ounce to be mixed with 5 ounces of water.
Manhu Infant Food	8·8	8·7	5·6	75·9	1·0	A mixture of desiccated milk and malted cereals. When prepared according to directions, contains a good deal of unaltered starch. A dessert-spoonful (=13 grammes) to be mixed with 2½ ounces of water.

[1] Calculated from total N by factor 5·7.

COMPOSITION OF INFANT FOODS—*continued.*

Food.	Water.	Proteid.	Fat.	Carbo-hydrate.	Mineral Matter.	General Description and Remarks.
GROUP II. *Class A.*						
Mellin's Food ..	6·3	7·9	trace	82·0	3·8	A completely malted food. All the carbohydrate in a soluble form. May be regarded as a desiccated malt extract ½ tablespoonful (about 5 grammes), ¼ pint milk, and ¼ pint water for a child under 3 months.
Class B.						
Savory & Moore's Food	4·5	10·3	1·4	83·2	0·6	Composed of wheat flour with the addition of malt. When prepared according to the directions, most, but not all, of the starch is converted into soluble forms (chiefly dextrins). 1 or 2 table-spoonfuls (= 1 to 2 ounces) to be mixed with 2 or 3 table-spoonfuls of cold milk or milk and water, and ½ pint of boiling milk, or milk and water, added.
Benger's Food ..	8·3	10·2	1·2	79·5	0·8	A mixture of wheat flour and pancreatic extract. When prepared according to the directions, most, but not all, of the starch is converted into soluble forms. The proteid is also partially digested as well as that of the milk used in mixing it. Take 1 tablespoonful (about an ounce) and 4 of cold milk, then add ½ pint of boiling milk and water; set aside in a warm place for 15 minutes, then bring to the boil.
Allenbury Malted Food	6·5	9·2	1·0	82·8	0·5	A mixture of wheat flour and malt. When prepared according to the directions, still contains some unaltered starch. Designed for children above 6 months. 1 tablespoonful (about an ounce), 1 teaspoonful of sugar, and 3 tablespoonfuls cold water; mix and add ½ pint boiling milk and water (equal parts).
Diastased Farina	8·3	8·3	1·3	81·0	1·1	A malted farinaceous food. When prepared according to the directions, practically all the starch is converted into soluble forms. 1 ounce of food, ½ pint of cold milk, and 2 ounces water. Heat

COMPOSITION OF INFANT FOODS—*continued.*

Food.	Water.	Proteid.	Fat.	Carbo-hydrate.	Mineral Matter.	General Description and Remarks.
						slowly till it boils; boil 3 minutes and sweeten if desired.
Coombs' Malted Food	7·9	12·1	2·8	76·8	0·4	A malted, farinaceous food. When prepared according to the directions, still contains much unaltered starch.
Nutroa Food ..	6·8	15·9	10·3	66·0	1·0	A mixture of cereals with the addition of a certain proportion of peanut flour, from which the somewhat bitter taste of the food and its high proportion of fat are derived. It is a self-digesting food, but when prepared according to the directions, only part of the starch is converted. 1 ounce of the food to be mixed with 1 ounce of cold water, and ½ pint boiling milk and water (equal parts) to be added
Albany	8·6	9·5	2·1	79·4	0·4	A self-digesting, farinaceous food for infants and invalids. To be used with equal parts of milk and water according to directions. Starch not all changed.
Worth's Perfect Food	2·4	11·1	2·0	83·5	0·5	A tablespoonful to be mixed with ½ pint of cold milk or milk and water, and boiled 5 or 10 minutes. When prepared according to directions, still contains unaltered starch.
GROUP III.						
Ridge's Food ..	7·9	9·2	1·0	81·2	0·7	A baked flour, containing only 3 per cent. of soluble carbohydrates, the remainder being starch. Recommended to be made with milk *or* water. Made with water alone is not a sufficient food.
Neave's Food ..	6·5	10·5	1·0	80·4	1·6	Resembles the above, but recommended to be made with milk and water.
Frame Food Diet	5·0	13·4	1·2	79·4	1·0	A thoroughly baked flour, to which has been added cane-sugar and some extract of bran (see p. 190). It is *not* specially rich in mineral ingredients, but nitrogenous matters are abundant, and it contains much unaltered starch. ⅛ ounce to be mixed with a breakfast-

COMPOSITION OF INFANT FOODS—*continued.*

Food.	Water.	Proteid.	Fat.	Carbo-hydrate	Mineral Matter.	General Description and Remarks.
						cupful of milk and water (1 of milk to 2 of water).
Opmus Food ..	10·9	9·1	1·0	78·6	0·4	A granulated wheat food. 1 teaspoonful to ½ pint of milk. Starch unaltered.
Falona	7·0	8·4	3·5	79·9	1·2	A mixture of cereals (oats, barley, and wheat) with a ground, fat-containing bean. The food is thoroughly baked, but contains a considerable proportion of unaltered starch. A teaspoonful to ½ pint of boiling milk *or* water, or half milk and half water.
Robinson's Groats	10·4	11·3	1·6	75·0	1·7	Ground oats from which husk has been removed. Rich in proteid and mineral matter.
Robinson's Patent Barley	10·1	5·1	0·9	82·0	1·9	Ground pearl barley, and of the same nutritive value as the latter.
Chapman's Whole Flour	8·4	9·4	2·0	79·3	0·9	A finely ground whole-wheat flour. Not much superior in nutritive value to ordinary 'households' flour. Starch entirely unaltered.
Scott's Oat Flour	5·8	9·7	5·0	78·2	1·3	A fine oat flour. Starch unaltered.
Nichol's Food of Health	11·9	7·7	1·7	76·9	1·75	To be used with equal quantities of boiling milk and water for making infant gruel.
Triticumina Food	8·6	12·5	2·2	75·7	1·0	To be made with equal parts of milk and water, with the addition of sugar.
'I. and I.' Food ..	5·5	10·3	2·3	80·5	1·4	An infants' and invalids' food To be made with water only, or half and half water and milk, and sweetened to taste.
Muffler's Food ..	4·7	13·8	5·0	74·1	2·4	Prepared from milk, wheat flour, and eggs; sterilized *in vacuo*. To be used with water or milk.

In judging of the value of these numerous preparations, one may divide them into the following groups:

1. *Foods prepared from cow's milk with various additions or alterations, and requiring the addition of water only to be ready for use.* This group includes:

'Allenbury' first and second foods.
Carnrick's Soluble Food.
Horlick's Malted Milk.
Nestlé's Milk Food.
Manhu Infant Food.

Comparing these preparations with the composition of dried human milk (see table), one observes that they are all deficient in fat and too rich in carbohydrate. In half of them, also, there is insoluble carbohydrate (starch) present, which is not suitable for infants (see p. 452). The composition of some of them when ready for use is contained in the following table, and fully bears out these criticisms:

	Human Milk.[1]	*Allenbury Food, No. 1.*[2]	*Nestlé's Milk Food.*[3]	*Malted Milk.*[4]
Water	87·60	88·30	92·76	92·40
Proteid	1·52	1·56	0·81	1·15
Fat	3·28	2·30	0·36	0·60
Sugar	6·50	7·20	3·80	5·38
Mineral matter ..	0·27	0·60	0·13	0·29

These foods may fairly be regarded as condensed milks carried a stage further; *i.e.*, they are desiccated milks. Some of them would correspond to unsweetened, whole condensed milks, others to partially or wholly skimmed and sweetened milks. None of them contains relatively as much fat as the best brands of condensed milk, and one cannot see that they possess any advantage over these. In their favour it must be admitted that their casein, like that of condensed milk, clots only loosely or not at all, and is therefore more easily digested than that of fresh cow's milk. Like condensed milk, too, they contain no antiscorbutic element and are very expensive, for it costs more than twice as much to feed an infant on any of these preparations than if one uses fresh milk. That is inevitable. The manufacturer must be paid for his trouble in removing the water which the consumer has to put back again.

2. The second group consists of *farinaceous foods prepared from cereals* (*usually wheat*), *of which the starch has been partly or wholly transformed into soluble substances* (*dextrins or malt-sugar*), and which require the addition of milk to fit them for use. The group may be subdivided into two classes:

(*a*) Those in which the starch has been transformed before reaching the consumer—*e.g.*, Mellin's Food.

(*b*) Those which contain malt or pancreatic ferment, which convert the starch when the food is mixed—*e.g.*, Benger's Food, Savory and Moore's Food, Diastased Farina, Allenbury Malted Food, Nutroa Food, Coombs' Malted Food, etc.

When one compares the composition of these foods with that of

[1] Camerer and Söldner's analysis.
[2] Analysis by the author.
[3] Analysis by Chittenden (*New York Medical Journal*, July 18, 1896).
[4] *Ibid.*

dried human milk, one is struck again by their great deficiency in fat (except in the case of Nutroa). They are also defective in mineral matter and proteid. If mixed with water alone, therefore, these foods could never be true substitutes for human milk. In all of them, however, the addition of some fresh cow's milk is recommended, although the proportion is often very small. They can only be of use in supplementing the diet of infants who are unable to digest much cow's milk, but the only elements they supply are carbohydrate and, to a less extent, proteid. Their addition to cow's milk seems also to aid the digestion of the latter, probably by acting mechanically on the curd, as barley-water does. They may also be regarded as useful (though costly) additions to the diet of the infant after its sixth month.

As regards the relative merits of the two classes into which the group is divided, it may be said that there is no advantage in a food in which the conversion of the starch only takes place during the preparation of the food for use. On the other hand, the disadvantages of such a plan are obvious, for the result is at the mercy of the skill and care of the mixer, and, as a matter of fact, the conversion of the starch in many of the second class is by no means complete, even when the directions are carefully followed (see last column of table).

It is undoubtedly better to use a food such as Mellin's, in which the conversion of the starch has been completely carried out in the process of manufacture. The composition of Mellin's Food, when mixed and ready for use, is as follows:

	Human Milk.[1]	*Mellin's Food.*[2]
Water	87·60	88·00
Proteid	1·52	2·62
Fat	3·28	2·89
Carbohydrate	6·50	5·98
Mineral matter	0·27	0·47

3. The third group includes *farinaceous foods in which the starch has not been predigested*. It includes such foods as Ridge's, Neave's, Frame Food Diet, Opmus Food, Falona, Chapman's Whole Wheat Flour, Robinson's Patent Barley and Groats, and others. These preparations are open to the same objections as those in the second group, with the additional disadvantage that they contain much starch which has either not been acted on at all or only rendered slightly more digestible by the process of baking to which most of

[1] Analysis by Camerer and Söldner.
[2] Analysis by Chittenden (*New York Medical Journal*, July 18, 1896).

them are subjected in the course of manufacture. Now, into the question to what extent infants are able to digest unaltered starch we need not enter here. One may admit that recent observations have shown[1] that even quite young infants are able to digest much more starch than was formerly believed. The practical fact, however, remains, that starch forms no part of the diet of a naturally-fed infant until, at least, after the cutting of some of its teeth; and, further, experience shows that the presence of unaltered starch in the diet of young infants is prone to excite disorders of the stomach and bowels.

A consideration of these facts renders it evident that foods belonging to this group should be avoided altogether before the infant has cut any teeth. Their addition to the diet after that period will undoubtedly furnish the child with an increased amount of proteid and carbohydrate, but such articles as rusks, bread-pap, oat flour, and rice[2] will do so quite as efficiently, are as easy of digestion, and have the practical advantage of being very much cheaper.

It may be convenient to sum up at this point what we have learnt as to the practical rules for guidance in the feeding of infants.

1. Breast milk is always to be preferred; 'humanized milks,' though right in theory, are not found to be perfect substitutes in practice.

2. If the child does not gain, or loses weight, on the breast, try mixed feeding, using the breast along with modified cow's milk.

3. If the breast is inadmissible, a healthy infant *may* be reared on pure sterilized cow's milk; a feeble infant will require modified cow's milk.

4. The simplest method of modification is by dilution plus the addition of cream and sugar; but where expense is no objection, one of the humanized milks or 'fettmilch' may be employed.

5. If the infant is unable to digest cow's casein, even when the milk is much diluted, partial peptonization may be employed.

6. Condensed milks should only be used temporarily or where fresh milk is unobtainable. The unsweetened varieties should be selected and over-dilution avoided. The addition of fat will always be necessary.

7. No proprietary food in the market possesses any real advantage

[1] See *Berlin. Klin. Woch.*, No. 10, 1895, and a paper by Carstens at the 67ten Naturforscher Versammlung zu Lübeck, 1895, *Med. Abth.*, p. 161, also Parker in Medical Society's Transactions, 1887, p. 319.

[2] The starch of oats and rice is more easily digested by infants than any other.

over the best brands of condensed milk, and they should all be avoided as complete foods for infants if fresh milk is obtainable.

If used as additions to a diet of milk, those only should be employed before the child has cut its teeth in which the starch is entirely converted into soluble forms. The patent foods in which the starch is unconverted possess no advantages as additions to the diet of older children over such simple articles as oat flour, rusks, and rice, and are considerably more expensive.

The Feeding of Older Children.

After weaning—which should take place about the tenth to twelfth month—the diet becomes of a more solid character. The same principles must be observed in its composition, however, as in the case of infants; that is to say, the building material and fat must be relatively more largely represented than in the diet of adults.

The importance of a sufficiency of proteid in the diet of children can hardly be exaggerated. Much of the feebleness, flabbiness, and pallor of the children of the poorer classes in large towns is no doubt due to a lack of it. There is reason also to believe that a similar deficiency may be a cause of the stunted and ill-developed bodies which such children often show. The dearness of meat is largely responsible for these conditions.[1]

The following computations have been made of the **amount of each nutritive ingredient required at different ages**[2]:

Age.	*Proteid.*	*Fat.*	*Carbohydrate*
1½ years ..	.. 42·5 grammes.	35 grammes.	100 grammes.
2 ,, ..	.. 45·5 ,,	36 ,,	110 ,,
3 ,, ..	.. 50 ,,	38 ,,	120 ,,
4 ,, ..	.. 53 ,,	41·5 ,,	135 ,,
5 ,, ..	.. 56 ,,	43 ,,	145 ,,
8 to 9 years	.. 60 ,,	44 ,,	150 ,,
12 to 13 ,,	.. 72 ,,	47 ,,	245 ,,
14 to 15 ,,	.. 79 ,,	48 ,,	270 ,,

Atwater's calculation is as follows:

A child under 2 years requires 0·3 the food of a man at moderate work.
A child of 3 to 5 years requires 0·4 ,, ,, ,, ,,
A child of 6 to 9 years requires 0·5 ,, ,, ,, ,,
A child of 10 to 13 years requires 0·6 ,, ,, ,, ,,
A girl of 14 to 16 years requires 0·7 ,, ,, ,, ,,
A boy of 14 to 16 years requires 0·8 ,, ,, ,, ,,

The **ratio** of building material (proteid) to carbohydrate and fat is as 1 : 4·2 – 4·8 in the average child's diet. In that of the adult at

[1] See also Clement Duke's 'School Diet,' second edition, chapter iii.

[2] Schröder, 'Ueber die Ernährung 8-15 jähriger Kinder,' *Archiv. f. Hygiene* iv. 39, 1886. See also diagram, p. 47.

moderate work it is as 1 : 5·3 – 5·5. It will be noted also that fat is relatively more abundant in the diet of the child. There is 1 part of fat to 3·7 of carbohydrate in the child's diet, while the proportion in the adult is 1 to 4 (Atwater), 1 to 4·8 (Moleschott), and 1 to 8·8 (Voit).

Roughly speaking, a child of five requires half as much fat and building material as a full-grown man doing a moderate amount of work, but only one-third as much carbohydrate; while a boy of fifteen will require as much of every ingredient as a full-grown man leading a sedentary life.

One must now say a few words as to the sources from which the different ingredients of the diet should be derived.

Even for some time after weaning, cow's milk should still be the chief source of proteid. It may be supplemented at the end of the first year by small quantities of yolk of egg, and chicken, fish, and a little underdone meat may gradually be added. These animal substances are the best sources of proteid, because they contain it in a concentrated and easily-digested form. It is possible, however, to rear healthy children on a diet the proteid part of which is almost entirely derived from vegetable sources,[1] especially if the child is able to lead an active and out-of-door life.

Thus, a German author has recorded the case of an institution in which only one-eighth of the proteid in the children's diet was derived from animal sources, and yet the inmates were all well nourished and fully developed. He attributes this good result to the fact that the children were working out of doors most of the day, and were accustomed to the diet from their infancy.

In most cases, however, it is safer to supply at least one-third of the total proteid required in an animal form.[2]

The best vegetable proteid-yielders for children are oats (oat flour, groats, and rolled oats), wheat (whole wheat flour, macaroni, semolina, or such patent wheat foods as Opmus and Florador), such preparations of maize as hominy and cerealine, and, amongst the pulses, lentil flour.

[1] See cases described by Schröder, *loc. cit.*, p. 453.

[2] 'During the period of growth,' says Clement Dukes ('School Diet,' p. 32), 'there should be a tolerably even balance between the amounts of farinaceous and vegetable food, with a large preponderance of animal food, the total supply required being largely in excess of that demanded by adults, in order to supply the material necessary for growth and development as well as wear and tear.' He is assuming, of course, that regular daily exercise is enforced. He is of opinion that growing boys should have meat twice a day—once to make good wear and tear, and once to provide for growth. The total daily allowance should be 9½ ounces of cooked meat.

Fat should be derived from such sources as good milk, butter, the yolk of egg, and bacon. Difficulty is often found in getting the child to take enough fat, but its importance in the diet is such that pains should be taken to educate the child in this respect. By giving it in a state of fine division the difficulty may often be overcome. Thus, butter spread on bread or mixed with mashed potato may be taken when more solid fat would disagree or be refused. Suet pudding also contains fat in an easily-digested form.

If any **carbohydrate** be added to the diet at all before the teeth are cut, it should, as we have seen, be in a soluble form. In other words, it should consist of some form of sugar or dextrin, starch being excluded. Even up to the end of the first year it is well to avoid purely starchy foods, unless in very limited amount. It is at this period that one of the patent foods, in which the starch is partially digested, may be of service. After the first year more solid starchy food may be given. Rice, potato and oat flour are the most easily digested forms. Biscuits or rusks, too, are more easily digested than ordinary bread, because the high degree of heat to which they have been exposed ruptures many of the starch grains, and converts part at least of their contents into soluble forms.

The following is an analysis of two such preparations:

Rusks (Montgomerie's)	*Dr. Jago's Analysis.*	Dorina Nursery Biscuits.	*Dr. Gregory's Analysis.*
Water	6·9	Water	7·94
Proteid	11·5	Proteid	9·41
Starch	60·4	Starch	47·33
Maltose	14·2	Maltcse	16·62
Other soluble matters	6·0	Dextrin	10·58
Phosphoric acid	0·3	Fat	9·88
Rest of ash	0·4	Ash	1·24

Robb's Nursery Biscuits are also a serviceable preparation of a similar sort.

Arrowroot, cornflower, Oswego, sago and tapioca are useful forms of starch, which may be given in the form of puddings, but they possess no advantage over rice, and it must be remembered that they are practically devoid of proteid.

Sugar is one of the most important forms in which carbohydrate can be added to the diet of children. The great reduction in the price of sugar which has taken place in recent years is probably one of the causes of the improved physique of the rising generation. The fear that sugar may injure children's teeth is largely illusory. The negroes, who live largely on sugar-cane, have the finest teeth the world can show. If injudiciously taken, sugar may, however,

injure the child's appetite and digestion. The craving for sweets which children show is no doubt the natural expression of a physiological need, but they should be taken with, and not between, meals. Chocolate is one of the most wholesome and nutritious forms of such sweets (p. 265). Jam is also an important vehicle for adding carbohydrate to the dietary. The claims of jam *versus* butter have already been considered (p. 133); but I would only point out here that so great is the importance of fat in the diet of childhood, and so few the forms in which it can be given when compared with the abundant choice of different varieties of carbohydrate, that one must on no account allow jam to replace butter, or even dripping, as the habitual accompaniment of the child's bread.

The **mineral matters**, which are so important for building up the bones, muscles and blood of the growing child, should be chiefly derived, during the first two years at least, from milk. Abundance of milk in the diet will ensure a sufficient supply of the three most important ingredients—lime, potash and phosphoric acid.[1] Eggs, too, are rich in these elements, and the yolk of egg especially shares with milk the advantage of containing much phosphorus in an organic form. Iron is contained in yolk of egg, the red meats, and in such vegetable substances as oatmeal.

The vegetable salts of potash, which occur so abundantly in fruits and green vegetables, are also of importance, and such articles should always find a place in the child's menu.

Of **beverages** it need merely be said that water is the only one suited for young children, but care should be taken that it is pure. Alcohol in all forms should be avoided as being entirely unnecessary for healthy children. Tea and coffee are also harmful to the susceptible nervous system of the child, but cocoa, made with plenty of milk, may be allowed, though it should be regarded, like milk, as a food rather than a beverage properly so called.

Schemes of diet for children of school age will be found in the work of Dr. Clement Dukes already referred to.[2]

The following examples of diets suited for young children are taken from a series given by Dr. Eustace Smith in his valuable work on 'The Wasting Diseases of Infancy' (chapter xii.). The *quantities* are not intended to be invariable, but must be suited to the needs and capabilities of each particular child.

[1] Dr. Ferguson, the factory inspector, concluded from careful continuous measurements of factory children that between thirteen and sixteen years of age they grow nearly four times as fast on milk for breakfast and supper as on tea and coffee.

[2] 'School Diet,' p. 174 *et seq.* (London: Rivingtons, 1899)

I. Diet for a Child about 10 Months Old.

First Meal, 7 a.m.

A tablespoonful of Mellin's Food.
A teaspoonful of Chapman's Flour (baked).
A breakfast-cupful of new milk.

Second Meal, 10.30 a.m.

A tablespoonful of pearl barley jelly dissolved in a breakfast-cupful of warm milk and sweetened with white sugar.

Third Meal, 2 p.m.

The yolk of one egg beaten up in a teacupful of milk and sweetened with white sugar.

Fourth Meal, 5 p.m.

Same as the second.

Fifth Meal, 11 p.m.

Same as the first.

II. Diet for a Child from 12 to 18 Months.

First Meal, 7.30 a.m.

A rusk or a slice of stale bread well soaked in a breakfast-cupful of new milk.

Second Meal, 11 a.m.

A drink of milk; a plain biscuit or slice of thin bread-and-butter.

Third Meal, 1.30 p.m.

A teacupful of good beef-tea (a pound of meat to the pint) or of beef-gravy, with rusk.
A good tablespoonful of light, farinaceous pudding.

Fourth Meal, 5.30 p.m.

Same as the first.

Fifth Meal, 11 p.m. (if required).

A drink of milk.

III. Diet for a Child from 18 Months to 2 Years Old.

First Meal, 7.30 a.m.

A breakfast-cupful of new milk.
A rusk or half a slice of bread soaked in the liquid fat of hot fried bacon.

Second Meal, 11 a.m.

A cup of milk and a biscuit.

Third Meal, 1.30 p.m.

Underdone roast mutton, pounded in a warm mortar, a good tablespoonful.
One well-mashed potato moistened with two or three tablespoonfuls of gravy.
For drink, filtered water or toast-water.

Fourth Meal, 5.30 p.m.

A breakfast-cupful of milk.
Thin bread-and-butter.

Dr. Smith also lays stress on the following points:

1. Intermediate meals should be avoided as far as possible, and

therefore care must be taken that enough food is given at the regular meals to supply all reasonable demands.

2. A healthy child between ten and twelve months old will require $1\frac{1}{2}$ pints of milk in the twenty-four hours. At eighteen months about 2 pints should be taken.

3. The fifth meal, at 11 p.m., should never be given unnecessarily, and the sooner a child becomes accustomed to sleep all night without food, the better. In such a case a drink of milk may be given immediately on waking. Many children between twelve and eighteen months old do well upon only three meals a day.

CHAPTER XXVII

THE PRINCIPLES OF FEEDING IN DISEASE

In this and the succeeding chapter we pass on to consider the use of food as a therapeutic agent in the treatment of the sick. In dealing with this part of the subject, it will be well to confine our attention as far as possible to the discussion of principles, and to avoid those detailed instructions for the dietetic management of particular cases which find their appropriate place in text-books of therapeutics. If the general principles involved are once fairly grasped, the knowledge we have already acquired as to the composition and uses of different foods should be sufficient to guide us in drawing up a dietary suited to any ordinary case of illness. Nor can one deal in such a book as this with the methods of preparing food for the sick, or invalid cookery, no matter how important some acquaintance with that art must always be to the practical physician.

From the point of view of dietetics, it will be convenient to consider cases of disease in the following groups: (1) Fevers; (2) disorders of metabolism, *e.g.*, diabetes, obesity, gout, etc.; (3) affections of the stomach and bowels; (4) disorders of the circulation and blood; (5) diseases of the organs of excretion.

Before, however, one passes to the separate consideration of these groups, it is advisable to point out a few **practical rules** which should always be present to one's mind in drawing up any scheme of diet for a patient. They are these:

1. In acute disease it is well to recommend a special plan of diet; in chronic cases it is often more convenient simply to forbid those articles which are likely to prove harmful.

The next two rules are corollaries to the first.

2. Before recommending any article it is well to ascertain whether the patient likes it, and how it agrees with him.

3. No article should be forbidden unless one has good reason for doing so.

4. Unless there is some strong contra-indication, attention should always be paid to the wishes and tastes of the patient. This rule was first formulated by Hippocrates in the aphorism, 'Such food as is most grateful, though not so wholesome, is to be preferred to that which is better, but distasteful'; and Sydenham recognised its value when he wrote: 'More importance is to be attached to the desires and feelings of the patient, provided they are not excessive or dangerous, than to doubtful and fallacious rules of medical art.'

5. If any article of food disagrees, it is better to reduce the quantity of it taken than to cut it out of the dietary altogether.

6. Changes of diet should, if possible, be made gradually.

7. One should never prescribe a diet for a patient without having first ascertained what his habits are as regards work and exercise.

These rules require no comment.

1. Principles of Diet in Fever.

There are few departments of practical medicine in which opinion has undergone a greater revolution than in the question of fever diet.[1] Hippocrates fed his fever cases simply upon wine and 'ptisan,' or thin barley gruel, and this lowering plan, first practised for centuries on the sole weight of his authority, was afterwards endorsed by the erroneous pathological doctrine first promulgated by Broussais, that fevers proceeded from irritation of the intestinal mucous membrane, and therefore demanded a starvation diet. His contemporary, Brown, though perhaps not much nearer the truth in his pathology, was better advised in his practice when he taught that fevers were 'asthenic' diseases, and required to be treated by liberal feeding. It was not until about the middle of the present century, however, that Graves, discarding all pathological doctrines, and guided simply by the results of observation, came to the conclusion that the popular starvation method was wrong, and introduced the modern practice, ever since adopted, of 'feeding fevers.'

The prevailing system at the present time may be fairly described as that of feeding a fever patient up to the limits of his digestive capacity with fluid or semi-fluid food, except, perhaps, in the case of some abdominal fevers. The reaction against the starvation plan has, it will be admitted, gone, if anything, rather too far, and the danger now is that too much rather than too little nourishment may be given.

[1] For a full account of the history of the subject, see J. Uffelmann, 'Die Diät in den Acut-fieberhaften Krankheiten,' 1877

Any lingering doubts as to the wisdom of the feeding plan tend to be dispelled by the results of recent research, which have shown (1) that the free administration of food does *not*, as was formerly supposed, tend to raise the temperature of feverish patients;[1] and (2) that the food is *not* merely poured into a digestive apparatus unable to deal with it, for the absorption of light articles of diet, at any rate, goes on almost as perfectly in the febrile as in the non-febrile state.[2]

Granted, then, that the liberal administration of food in fever is justified on grounds alike of experience and pathology, we have next to inquire, **What nutritive constituents should the diet of fever chiefly contain?**

A study of the metabolic changes in fever may be expected to afford us some light here. Extensive investigation into these changes in recent years has tended to show that the leading characteristic of the metabolism of fever is a great increase in the destruction of nitrogen-containing tissues, while the mainly carbonaceous components of the body, such as fat, are affected in a much smaller degree.

The reason for the increased destruction of nitrogenous tissues in fever appears to be twofold: Firstly, and probably mainly, it is due to simple inanition, to the fact that less food is reaching the tissues than is required to meet their output of heat. In part, however, it seems also to be due to the fact that the 'toxins' which produce fever exert a specially destructive influence on the proteid constituents of the body.

This being so, it seems natural to suppose that the chief dietetic indication in fever must be to supply a large proportion of proteid in the diet. Actual observation, however, has shown that it is impossible to bring about a condition of nitrogenous equilibrium in acute fevers on any feasible quantity of food. The reason for this probably is, that although one may cover the waste which is due to simple inanition, it is impossible to prevent that which is brought about by the destructive action of toxins on the cells. Practically, therefore, the administration of a large quantity of proteid in the diet fails to achieve the desired result, no matter how strongly it may be indicated theoretically. The consumption of much nitrogenous food has also this disadvantage, that it tends to flood the circulation with

[1] Von Hoesslin, *Virchow's Archiv.*, lxxxix. 95, 303, 1882. He found that in cases of typhoid the temperature on days when food was administered was only from 0·11° C. to 0·3° C. higher than on starvation days.

[2] *Ibid.* See also Leyden's 'Handbuch der Ernährungstherapie,' p. 403.

the products of nitrogenous waste, already too abundantly present, thus increasing the strain thrown upon the kidneys, and at the same time, in all probability, tending to bring about a condition of toxæmia, to which some of the symptoms of fever are no doubt due.

We shall, therefore, better attain our object of limiting proteid destruction by seeing that the 'proteid-sparers' are abundantly represented in the diet rather than by devoting too much attention to the proteids themselves.

Now, the proteid-sparers, as we have seen, are, in order of their importance, gelatin, carbohydrates, and fats. The use of the first of these is restricted by the fact that the end-products of its destruction are so similar to those of proteids that they may be expected to produce the same results as these in the circulation, while the employment of the last is rendered impracticable by the insuperable repugnance which feverish patients exhibit to fatty foods. We therefore arrive at the conclusion that **the diet of fever should contain a liberal supply of carbohydrates.**

The contention that mineral matters should also be freely represented—a contention based entirely upon theoretical grounds—has already been dealt with (p. 103).

These being the dietetic indications derived from a study of the morbid metabolism of fever, we may next proceed to inquire how they may best be put into practice.

And firstly, by common consent, the diet of fever **is a fluid diet.** This is not merely grateful to a thirsty patient, but evades the necessity of chewing, which the diminution of the salivary secretion renders difficult. It has also the advantage of supplying much water to the tissues, of which in fever they seem to stand specially in need. Milk is the simplest, most accessible, and most nutritious of fluid foods, and should always form the basis of the diet. Four pints of it a day will supply about 1,700 Calories of energy to the body, and this, though quite insufficient for the needs of health, is usually enough to meet the demands of a patient confined to bed, especially in fevers of short duration, where the body can afford to draw to some extent upon its own resources. The milk may be given plain or diluted with some alkaline or effervescing water or lime-water. If the patient tires of it, it may be flavoured with a little cold coffee or with caramel or malt extract. If it produces vomiting or diarrhœa, it may be necessary to give it peptonized or to substitute koumiss.

If less than 3 pints of milk can be got down in the day, nutrition is likely to become seriously impaired, and in that case it may be

well to '**fortify**' **the milk**. The amount of proteid in it may be increased by the addition of such preparations as Nutrose, Plasmon, or Somatose, or the proportion of fat may be raised by the addition of cream. For the reasons already given, however, it is better to enrich the milk chiefly by the addition of some carbohydrate. Of these milk-sugar is one of the simplest and best, and is probably not sufficiently made use of. One or two teaspoonfuls dissolved in a little hot water may be added to each tumblerful of milk. The value of sugar in fevers has been specially insisted upon by Fick;[1] and, of all forms of it, milk-sugar, from the comparative absence of sweetness which characterizes it, is probably best.

Instead of using sugar, the milk may be enriched by the addition of some cereal preparation, such as oat-flour, arrowroot, or corn-flour, made in the form of a thin gruel. Many of the patent foods, such as Benger's, Nestlé's, or Malted Milk, may here play a useful part, while some patients find the addition of malt extract agreeable; a tablespoonful of it may be added to each ½ pint of warm milk. In any case, it is well to employ these different devices in turn, for patients quickly tire of any one of them.

In addition to milk, soups, beef-tea, or broths may be allowed in the proportion of about 1 pint a day, but it should be remembered that their chief use is as exciters of appetite, and perhaps as slight stimulants, rather than as foods. They may also be made the vehicles for conveying carbohydrates into the body by thickening them with baked flour or some other simple farinaceous preparation, or with one or other of the patent proteid or carbohydrate foods. Where diarrhœa is present, the use of soups, etc., containing meat extractives is better avoided.

The consumption of beef-juices in fever, though very popular, is to be deprecated for the reasons given in another chapter (Chapter VI.); but the egg-white mixture already described (p. 99) may sometimes be a useful aid in cases where very little food can be taken at one time, and where vomiting is urgent.

Jellies may also be allowed in moderation, those flavoured with wine being perhaps the best, but it must be recollected that their nutritive value is but small.

As regards the **intervals at which food should be given in fever**, one must be guided chiefly by the digestive powers of the patient. It is well to begin with small quantities—say a wineglassful of milk—every hour or so, and gradually feel one's way till a tumblerful can be taken every two hours. Beef-tea can be given after every

[1] *Zeit. f. Klin. Med.*, x. 531, 1886.

two of the milk-feeds, as a change. As far as possible the administration of food should be confined to the day hours, a little drink only being allowed during the night; but if the patient is much exhausted it may be necessary to feed by night also.

Cold water is the best beverage in fever, but though the total amount of it need not be restricted, it is well only to allow a few sips of it at one time. The excessive consumption of aerated beverages is to be avoided, as tending to overdistend the stomach with gas. In addition to water, milk-sugar lemonade (a teaspoonful to the tumbler, flavoured with a squeeze of lemon-juice), fruit drinks—*e.g.*, raspberry vinegar and water—or Imperial Drink, are all refreshing, and may be made the means of conveying some sugar into the stomach.

Where there is any tendency to looseness of the bowels, however, it is well to restrict the drink to plain water or barley-water. A cup of tea or coffee may also be allowed if the patient desires it, especially in the early morning, and is probably too often forbidden without any sufficient reason.

The use of alcohol in fevers is an important matter which calls for some special discussion. Hippocrates recognised the value of wine in fever, and since his time it has been pretty generally employed. Stokes of Dublin laid down certain imperative indications for its use, and his colleague Graves devoted one of his clinical lectures to a consideration of the place which it should take in the general treatment of fever. The advantages of stimulants, however, were insisted upon more strongly by Todd,[1] who wrote about the middle of this century, than by any preceding English author, and the present general recognition of their utility is no doubt largely due to his strenuous advocacy. Indeed, it may be questioned whether in this case also the reaction in favour of a 'stimulating' treatment of fevers has not gone too far, and the administration of alcohol become too much a matter of routine. In a previous chapter we have learned that alcohol has a stimulating influence upon the heart, that it reduces body temperature by dilating the surface blood-vessels, and that it is in itself at the same time a source of energy, and diminishes tissue waste, especially the waste of fat. All of these properties mark alcohol out as an agent likely to be useful in the treatment of such a condition as fever. It would be a mistake, however, to suppose that it requires to be made use of in every case.

[1] 'Clinical Lectures on Certain Acute Diseases,' London, 1860. Lecture xiv., 'On the Therapeutical Action of Alcohol.'

Clinical observation has shown that it is only imperatively demanded when the following indications are present:

1. Failing circulation, as exhibited (1) in a persistently rapid pulse (120 or more), or if it be weak, irregular, unequal, or dicrotic; (2) by a faint or inaudible first sound of the heart.[1]

2. Nervous exhaustion, as manifested by sleeplessness, low delirium, and tremors.

3. Failure of digestive-power, as indicated by inability to take food, diarrhœa, and dryness of tongue.

4. High temperature, especially if persistent.

5. A bad general condition—*e.g.*, in feeble, exhausted, elderly, or alcoholic subjects.

In some special diseases—*e.g.*, malaria, erysipelas, and septic poisonings, alcohol seems to increase the resisting-power of the patient and is almost always indicated on that account.

The **form in which alcohol should be given in fevers** is not a matter of indifference. If one merely wishes to obtain its effects upon the temperature and circulation, any pure form of spirit will do. Sound malt whisky is as good as any other. Where, however, there are signs of nervous exhaustion—as, for example, in the 'typhoid state' —a preparation rich in volatile ethers should be selected. Of these *genuine* cognac is one of the best, and it is worth while to pay a high price for it in order to be sure of having it good. The ordinary so-called brandy is no better than whisky. Possibly the Spanish brandy recently introduced may prove useful, as it is said to be rich in ethers. Failing good brandy, one may fall back on one of the stronger wines, and of these old sherry is more highly ethereal than any other.[2] In catarrhal conditions, and where a tendency to vomiting is present, an effervescing wine, such as good, *dry* champagne, often gives the best results. In some forms of delirium, on the other hand, such as that due to alcoholism, bottled stout seems to exert a peculiarly sedative influence.

In deciding upon the **amount of alcohol to be given, and the frequency of its administration**, one must be guided chiefly by the urgency of the indications calling for its use. Half an ounce of spirit, diluted with twice as much water, or an ounce of one of the stronger wines, may be given every four, three, or two hours, according to the effect produced, or even every hour if occasion demands it. Careful observation of the case will generally show whether the right amount

[1] See Stokes, *Dublin Med. Journ.* (1st series), vol. xv., p. 1, 1839.
[2] See Anstie, 'On the Use of Wines in Health and Disease,' p. 44; London: Macmillan and Co., 1877.

is being administered. As long as the pulse is becoming slower and steadier, the skin and tongue more moist, the appetite better, and the patient quieter and calmer, the alcohol is doing good. The results of excessive dosage will usually first manifest themselves in the digestive organs in the form of flatulence, eructation, and dryness of the mouth, with the appearance of sordes on the lips. A tendency to coma, and a persistent smell of alcohol in the breath, are also signs that too much is being given. Finally, it may be well to remember the dictum of Todd, that it is safer to give too much than too little, and to begin too early rather than to leave off too soon.

Diet in Special Fevers.

The principles of diet described in the preceding pages are applicable to the majority of cases of fever, but in some one requires to introduce modifications. As has already been mentioned, the use of beef-tea and all fluids containing the extractives of meat is best avoided in cases in which there is diarrhœa. The same holds good for **rheumatic fever**. In that disease preparations derived from meat are generally held to be injurious, and the diet during the height of the attack should consist of milk alone or diluted with some alkaline water. Alcohol, also, is usually unnecessary, and to be avoided in these cases.

The dietetic treatment of **typhoid fever** is described in so much detail in all text-books of medicine that it need not be fully described here. It is sufficient to point out that the majority of observers are in favour of a strictly fluid diet, consisting mainly of milk, in that disease, and many recommend that even milk should not be allowed in large amount.

It is difficult to justify such a strict diet on any grounds other than those of experience. The widely-spread impression that solids are injurious on account of the danger of their irritating the intestinal ulcers, and predisposing to hæmorrhage and perforation, can hardly be defended, for, as we have already seen (p. 411), the intestinal contents, by the time the lower end of the ileum is reached, are always in a fluid form.

In recent years a revolt against the orthodox practice has taken place, and a more abundant diet has been advocated, the extremest supporter of the new view being the Russian physician Bushuyez. The diet which the latter has adopted is certainly an extremely liberal one. The following is the scheme of it:

a.m.: Tea and a roll.
8 a.m.: 14 oz. of gruel (oatmeal, barley or wheat) with butter.
9 a.m.: One or two boiled eggs.
10 to 11 a.m.: A glass of milk, a roll, half a cutlet and a bit of boiled meat.
12 to 12.30 p.m.: A bowl of soup and a little jelly.
3 p.m.: Tea and a roll.
6 p.m.: A cup of soup, a bit of chicken, and milk pudding.
8 p.m.: A roll and milk.
During the night coffee or tea with milk is allowed several times.

In 318 cases in which this diet was adopted the mortality was only 8·2 per cent.; not a single case was lost from hæmorrhage, while the general condition of the patient was much better than that of those fed on the orthodox lines. All the patients were allowed to sit up in bed, and many were able to walk a little.

A recent paper by Dr. Morris-Manges[1] contains a full account of the results yielded by the new diet. The writer himself used a diet consisting of milk, soft-boiled eggs, custard, jellies, chicken, rice, baked potatoes, and strained cereal gruels, in eight cases. He states that the stools were always well digested, that the diarrhœa was not increased, and that subsequent emaciation and anæmia were very slight. He had 25 per cent. of relapses, but this, as he points out, is much higher than that found by Bushuyez and others in a much more extended series of cases.

Without going so far as to endorse such an extreme departure from established practice, it may be admitted that the results yielded by the new method of treatment cannot easily be explained away, and are calculated, to say the least, to awaken suspicion that the classical diet of typhoid is needlessly spare. At all events, a more extensive trial of liberal feeding in that disease is strongly indicated.

2. Disorders of Metabolism.

DIABETES.

Whatever view one may hold as to the true pathology of diabetes, there is almost universal agreement as to the value of restricting the intake of carbohydrates in that disease. It may be objected that, even if one succeeds in doing this to the point of causing all sugar to disappear from the urine, one has thereby only masked the most prominent symptom of the disease, without in any way striking at the root of the complaint. To this it may be replied:

1. That clinical experience has shown that in many cases, by withdrawing all carbohydrates from the diet for a time, one can

[1] *New York Medical Record*, January 6, 1900

succeed in re-educating the tissues in their power of dealing with sugar, at all events to some extent, and that a return to an ordinary diet is then no longer accompanied by a corresponding increase in sugar excreted.[1]

2. Even were it the case that limitations of carbohydrate ingestion had no truly curative influence, there can be no doubt that many of the most distressing symptoms of which diabetics complain, and most of the complications which may cut short their lives, are due, not to the disease *per se*, but to the presence of an excess of sugar in the circulating fluids.

It being granted, then, that limitation of the carbohydrates in the diet of diabetes is justified, one has next to ask: How are they to be replaced?

The importance of this question will be obvious when one reflects that most people are in the habit of obtaining at least one-half, and sometimes even three-fourths, of their total daily supply of energy in a carbohydrate form. Obviously, then, some other source of energy must be found, unless one's patient is to be starved to death, and practically one has to choose as the substitute for carbohydrate either proteid or fat. As to the relative merits of these two substitutes, there is not much difficulty in coming to a decision. Fat is a compact source of energy, and yields, for a given weight, two and a quarter times as many Calories as proteid. In all probability, too, it cannot act in itself as a source of sugar. Proteid, on the other hand, is more bulky, it can certainly produce sugar, and there is besides good reason to believe that the products of its decomposition favour the production of acetone in the blood, and may lead to diabetic coma. In addition to this fat can, to a considerable extent at least, fulfil the proteid-sparing function of carbohydrates, and is thus in every way calculated to serve as a substitute for these in the food.[2] We conclude, then, that **richness in fat** must be the leading characteristic of a rational diabetic diet.

The next question which arises is this: **To what extent are the carbohydrates to be restricted?** Are they to be abolished from the diet altogether, or only reduced in quantity? Before a reply to this question can be given, one must ascertain the severity of the case

[1] For evidence bearing upon this point, see Von Noorden, Leyden's 'Handbuch der Ernährungstherapie,' p. 442

[2] I am aware that Dunlop ('Dietetic Value of Fat in Diabetes,' *Edin. Med. Journ.*, November, 189[illegible]) has advanced evidence in one case to show that fat does not exert its usual proteid-sparing action in diabetes, but the bulk of the clinical evidence available is opposed to such a conclusion.

with which he has to deal, for there are cases of diabetes *and* diabetes, and in some the tissues have lost their power of assimilating carbohydrates completely, while in others that power has only undergone some impairment.

In order to discover to which of these classes the patient belongs, he must be put on a **test diet** from which carbohydrates are altogether excluded. A diet of meat, fish, eggs, green vegetables and butter answers the purpose quite well. The patient is restricted to this for about ten days, and his output of sugar carefully estimated. If he still continues to excrete sugar, one concludes that he belongs to the severer group of cases, those, namely, in which sugar is produced from proteids in the tissues themselves. If sugar disappears from the urine completely on such a diet, the tissues have probably not lost their power of dealing with carbohydrates altogether. One has then to ascertain, by the gradual addition of known quantities of bread to the diet, what the patient's tolerance for carbohydrates really is. The larger the amount of bread which can be added without causing sugar to appear in the urine, the milder is the case. One or two examples may serve to illustrate this method of procedure:

CASE 1: MAN (aged 51):

	Average Quantity of Urine.	*Sugar.*
Strict diet	2,000 c.c.	65 grammes.
,, ,, +2 oz. of bread and 1 oz. of potato	2,900 ,,	80 ,,

This was evidently a severe case, with tolerance considerably below nil.

CASE 2: WOMAN (aged 33):

	Average Quantity of Urine.	*Sugar.*
Strict diet	1,000 c.c.	22 grammes.
,, ,, +2 oz. of bread	2,020 ,,	88 ,,

This, also, was a severe case.

CASE 3: MAN (aged 60):

	Urine.	*Sugar.*
Ordinary hospital diet	2,850 c.c.	178 grammes.
Strict diet, 1st day	1,500 ,,	68 ,,
,, ,, 2nd ,, ...	950 ,,	24 ,,
,, ,, 3rd ,, ...	850 ,,	11 ,,

This was a much milder case, and had the strict diet been continued for some time longer, sugar would probably have d appeared altogether.

The subsequent regulation of the diet must be determined by the class of case to which the particular patient belongs.

If he can take 2 ounces of bread without glycosuria resulting, he may be allowed that or its equivalent in some other carbohydrate containing food. If 3 ounces of bread are borne, allow 3 ounces or its equivalent, and so on.

If, on the other hand, sugar disappears from the urine on the strict diet, but reappears whenever the smallest quantity of carbohydrate is added, his diet must consist exclusively of proteid and fat.

In the third class of case, that in which sugar continues to be excreted even on a carbohydrate-free diet—and to this class most of the diabetics seen in hospital practice seem to belong—then a somewhat different method of procedure is called for. It is *not* wise to restrict the carbohydrate part of the diet in such cases too rigidly. Experience has shown (1) that although in such cases a restricted diet may reduce the amount of sugar in the urine, yet the general condition of the patient suffers, and he is apt to lose weight; (2) that, strange though it may appear, a few at least of these cases actually excrete more sugar on a diet rich in proteid than on one in which part of the proteid is replaced by carbohydrate. In the opinion of many good observers, too, such patients are more apt to develop diabetic coma on a very strict diet than on one which is more lax; this, however, may only be true where the carbohydrate is chiefly replaced by proteid rather than, as it should be, by fat.

There is also the practical difficulty that in the cases belonging to the last group proteids must be so much restricted that an enormous consumption of fat is necessitated if nutrition is to be adequately provided for, and it is difficult to persuade the patient to take the necessary quantity unless some carbohydrate (such as bread or potato) is allowed as a vehicle for carrying the fat.

Summing up what has been said above, one may conclude:

1. That in mild cases of diabetes the diet should contain a somewhat greater amount of proteid than normal, along with a large proportion of fat and as much carbohydrate as can be tolerated without the appearance of sugar in the urine.

2. In the more severe cases in which, on a carbohydrate-free diet, the sugar disappears, but comes back again whenever any starchy food is taken, the diet should resemble the above, but should contain an extra quantity of fat.

3. In the severest cases of all, in which sugar is excreted in the urine even although there be no carbohydrate in the food, the diet

should consist of a somewhat smaller proportion of proteid than normal, along with a small amount of carbohydrate and as much fat as the patient can be induced to digest.

It will be evident from these considerations that **there is no such thing as 'a diabetic diet.'** Every case of the disease must be treated on its merits, and any routine system of diet is to be carefully avoided.

We may now consider in greater detail what foods are available as sources of each constituent.

1. *Proteids.*—With regard to these there is no difficulty. The patient has the whole animal kingdom to choose from, though, in cases where a very strict diet is being enforced, it is well to avoid such articles as oysters, liver and sausages, all of which contain, or may contain, some carbohydrate. As a rule, the fatter meats and fishes are to be preferred to the leaner. Of milk products, cheese may be allowed in every case, and Devonshire cream may also be regarded as harmless. The use of milk itself will be considered more fully immediately.

2. *Fat.*—The best sources of fat are butter or margarine, bacon, the fatter meats (*e.g.*, pork), and fish (*e.g.*, eel, mackerel, and sardines in oil), suet, dripping, salad oil, eggs, cheese and thick cream. Of these butter should always be largely represented in the diet. There should be no difficulty in getting a patient to eat ¼ pound of it in the day, and in some cases one can get down 6 ounces, or even more.

If a small quantity of carbohydrate is allowable in the diet, the administration of fat is much facilitated, for the carbohydrate-containing food can be made use of as a carrier of fat. Thus, toasted bread may be soaked in butter or bacon-fat, or potatoes may be made into a purée with butter and cream. A given quantity of mashed potato, if cooked by steam, should easily take up half its weight of butter and a quarter of its weight of thick cream.

If carbohydrate foods are rigidly excluded, one has more difficulty in persuading the patient to swallow an adequate quantity of fat. In such a case green vegetables must be our chief resource as a fat-carrier. Mashed greens, from which the water has been removed as far as possible by squeezing in muslin, should easily take up one-third of their weight of fat, and salads can be covered with about one-fifth of their weight of oil without becoming unduly greasy. Eggs, too, can be made rich in fat by 'scrambling' them with plenty of butter, and melted butter can be used as a sauce for white fish.

By these devices, and by the liberal use of fat bacon, thick cream and cheese, one can usually get down a sufficiency. It is worth remembering that the use of alcohol at meals greatly aids the digestion of fat, and some writers recommend the administration of chalk (30 grains thrice daily) with the same object. I have certainly seen cases where this seemed to make the fat better borne, but it is apt to produce constipation, which of course is a thing to be carefully avoided in diabetics.

In some cases it may be necessary to have recourse to the administration of cod-liver-oil in order to supplement the fat of the diet, but as far as possible this should be avoided. Petroleum emulsion, which is sometimes recommended for a similar purpose, is, as the writer has shown elsewhere, perfectly useless as a food.

3. *Carbohydrates.*—Green vegetables contain so little carbohydrate that they may be allowed in every case. Asparagus, celery, young rhubarb, tomatoes, vegetable marrow, cucumber and mushrooms may also be regarded as harmless. If the richer carbohydrate foods are allowed, bread and potatoes should be selected, as the deprivation of these is always keenly felt by the patient.

It is important to remember that potatoes contain only about one-third as much starch as bread, and so may be given much more freely than the latter. If, for instance, a patient is capable of taking 2 ounces of bread daily, he may be allowed 6 ounces of cooked potatoes instead, if he prefers it. As the fat-carrying power of potatoes is so great, such a substitution is often an advantage.

If one wishes to use other carbohydrate foods instead of bread, the following equivalents are worth bearing in mind:

2 oz. of bread contain as much carbohydrate as 2 oz. of pea or lentil flour.
2 oz. of bread contain as much carbohydrate as $1\frac{7}{10}$ oz. of rice.
2 oz. of bread contain as much carbohydrate as $1\frac{1}{2}$ oz. of oat, barley, or maize flour.
2 oz. of bread contain as much carbohydrate as $1\frac{3}{8}$ oz. of cornflour, arrowroot, sago, tapioca or rice flour.
2 oz. of bread contain as much carbohydrate as 10 to 15 oz. of the sweeter fruits.
2 oz. of bread contain as much carbohydrate as 40 oz. of apples.

Iceland and Irish moss, which are often recommended for diabetics, are, as has been shown elsewhere (p. 259), almost entirely devoid of nutritive value.

4. *Albuminoids.*—The use of gelatin is quite permissible in all cases of diabetes, but the amount of nourishment which can be obtained in that form is very small. Jellies, of course, must be made without sugar. They can be flavoured with wine and sweetened with a little saccharin.

Some Special Articles of Food in Diabetes.

1. **Milk.**—Opinions differ as to the place which milk should occupy in the dietary of diabetes. The real question is whether or not milk-sugar is capable of assimilation by diabetics. Some authors have asserted that it is, and Donkin[1] even went so far as to recommend a purely skim milk diet in diabetes, and has recorded some apparently excellent results from that plan of treatment. He states that such a regimen either greatly reduces or even altogether banishes the sugar in the urine. He is careful to point out that if cream or butter or any nitrogenous food is taken at the same time one does not get these effects. The maximum quantity allowed was 12 pints a day, and he insists that the milk should be fresh, not boiled.

Whilst some of the results recorded by Donkin are very striking, it must be admitted that other observers have failed to confirm them, although recently Winternitz and Strasser have reasserted the value of the treatment, even in severe cases.[2] On the other hand, experiments made by the subcutaneous injection of sugars in diabetes have failed to show that lactose is assimilated in that disease.[3]

Whatever the ultimate opinion as to the value of an exclusively skim milk diet in diabetes may be, there is pretty general agreement that the addition of milk to an ordinary dietary in diabetes causes a considerable increase in the amount of sugar excreted. The following case, that of a middle-aged man with a severe form of the disease, may serve as an illustration:

Diet.	*Urine.*	*Sugar.*
Meat and fat + 3 oz. of bread	1,500 c.c.	60 grammes.
Meat and fat + 3 oz. of bread and 3 pints of milk	2,820 ,,	125 ,,

It is true that, even although the amount of sugar is increased, the patient often feels better and his weight rises when milk is allowed, and on that account many observers advocate its presence in the diet.

Fortunately, however, one can easily obtain all the advantages of milk without its disadvantages by getting rid of the sugar which it contains, while leaving the casein and fat. One then gets what may, for convenience, be termed **diabetic milk.** Methods of

[1] 'On the Relation between Diabetes and Food;' London: Smith, Elder and Co., 1875.
[2] *Centralb. f. Inn. Med.*, p. 1137, November 11, 1899.
[3] Achard and Weil, *Archiv. de Méd. Expér.*, x. 816, 1898.

preparing such milk have been described by Wright[1] and by Ringer,[2] while a very similar fluid, the chief ingredients of which are cream-fat and egg-white, has been elaborated by Williamson ;[3] in Germany, also, Von Noorden has advocated the employment of a similar artificial milk.[4] With the assistance of Mr. Morris, Chief Dispenser to the London Hospital, the author has succeeded in preparing a modified milk which contains merely a trace of sugar, and which has given excellent results in several cases. The following are the directions for making it:

Sugar-free Milk for Diabetic Feeding.

Take 1 litre of skim milk, heat to a temperature of 38° C., and add 10 c.c. of glacial acetic acid, diluted with 100 c.c. of water. Mix, and allow the mixture to stand for about fifteen minutes. Collect the separated casein, and let it drain on very fine muslin, using no pressure.

Remove the casein to a mortar, rub into a smooth paste, add ½ litre of distilled water, and strain as before. Repeat this washing of the casein twice. Transfer to a mortar, rub until quite smooth, and add 2·5 grammes of potassium hydrate dissolved in 100 c.c. of water (or as much of the KHO as is necessary to make the product just alkaline to phenolphthalein).

Add 100 grammes of ordinary Devonshire clotted cream, 5 grammes of gelatin previously dissolved, ·06 gramme (1 grain) of saccharin, and water, at about 38° C., up to 1 litre. Lastly, strain through fine muslin.

The product tastes very much like ordinary cow's milk, and can be taken either plain or with some effervescing water, or it can be added to tea or coffee or made into custards with eggs. In some cases as much as 5 pints of it have been taken in one day, and it does not seem to have any appreciable effect in increasing the output of sugar. In one case a patient on very strict diet excreted 1,000 c.c. of urine daily containing 22 grammes of sugar. On 5 pints of 'diabetic milk' and four eggs he excreted 1,630 c.c. of urine with 28 grammes of sugar. Another patient on a fixed diet containing a known quantity of carbohydrate and 1 pint of ordinary milk excreted 3,350 c.c. of urine with 180 grammes of sugar. When the ordinary milk was replaced by diabetic milk, the quantity of urine fell to 2,450 c.c., and the sugar to 125 grammes.

The use of such a milk will be found to be a very great aid in feeding diabetics, especially when they are unable to take much meat. It is probable, too, that the administration of proteid in the form of casein will be less likely to render the patient liable to the

[1] *Brit. Med. Journ.*, April 11, 1891.
[2] *Ibid.*, December 7 and 14, 1895.
[3] 'Diabetes Mellitus,' p. 334; Edinburgh and London: Young J. Pentland, 1898.
[4] Leyden's 'Handbuch der Ernährungstherapie,' p. 475.

dangers of acetonæmia than when it is given in the form of other animal foods.

Of milk products, **cream** can usually be allowed to diabetics, and the thicker it is the better. Devonshire cream is a specially valuable form. **Junket**, on the other hand, contains a considerable quantity of sugar, and is best avoided. **Koumiss** and **kephir**, though containing considerably less sugar than ordinary milk, are still fairly rich in it, and should be forbidden in any case in which the diet requires to be at all strict.

2. **Diabetic Breads.**—In recent times a large variety of breads have been specially devised for the use of diabetics. For the most part these are compounded of eggs, along with some vegetable substance more or less free from starch.

Of such substances, gluten, the chief proteid of wheat, was one of the first to be employed,[1] but more recently the oily nuts (such as the almond, cocoa-nut, and hazel-nut), bran, and the soja bean, have also been pressed into the service.

Of these products it may be remarked, in the first place, that many of them—and this applies specially to the gluten breads—are by no means free from starch; while in the case of others the chief ingredient is cellulose, which, of course, yields no nutriment to the body. Indeed, the only really valuable substance which they contain is fat, of which the bread may be regarded as a carrier. This is especially true of the almond and nut breads. Bran, being incapable of digestion in the human intestine, can serve no other purpose than that of adding to the bulk of the diet. This fact, that the greater part of many diabetic breads is composed of wholly non-nutritive matter, has not, I think, received the attention which it deserves.

In addition to these objections, one may say of all 'diabetic breads' that they are very expensive, and of most of them that they are extremely unpalatable, and that patients quickly tire of them.

In quite recent times casein has been adopted as a basis for diabetic bread, and a loaf has been prepared by the Protene Company which is entirely free from carbohydrate. If given in the form of toast, this bread is taken quite freely by most patients, and may be made the means of enriching the diet in proteid and fat without directly increasing the output of sugar. In a recent case which the writer had under observation, Protene Diabetic Bread was substituted for its equivalent of a so-called gluten bread, with the result that the amount of sugar in the urine fell 20 grammes. Although by no

[1] See Bouchardat, *Comptes Rend.*, xiii, p. 942, November, 1841.

means a perfect substitute for ordinary bread, it certainly seems to approach more nearly to the ideal than any other yet invented.[1]

3. **Special Forms of Carbohydrate in Diabetes.**[2]—Of all forms of carbohydrate, grape-sugar is less perfectly assimilated by diabetics than any other. Next to it come starch and cane-sugar, the latter of which is always to be avoided. Inulin is said to be well borne in mild cases, but is not of much practical dietetic importance. It is present in small amount in the Jerusalem artichoke and other Compositæ. The assimilation of lactose has already been referred to.

Much discussion has taken place as to the value of lævulose for diabetics.[3] While the earlier reports of its utility were considerably exaggerated, there is no doubt that diabetics utilize it better than any other form of carbohydrate.

The chief importance of lævulose is as a constituent of fruits, in

[1] The following analyses of Protene products are supplied by the company:

COMPLETE ANALYSIS OF PROTENE PRODUCTS.

Name of Product.	Percentage Composition.				
	Nitrogenous Matter (Proteids).	Carbohydrates (Starch, Sugar).	Mineral Salts.	Non-nitrogenous Matter[1] (Fats, etc.).	Moisture.
Protene Wheat Flour	25	60	3	1	11
Protene Household Bread (White)	25	43	2	—	30
,, ,, ,, (Brown)	25	30	3	—	42
Protene Diabetic Bread[2]	65	a trace	4	15	16
Protene Almond Bread[2]	60	—	4	11	25
Protene Gingerbread	25	54	2	5	14
Protene Diabetic Gingerbread[2] ..	40	18	2	29	11
Pure Protene Biscuits[2]	60	a trace	4	28	8
Protene Medical Biscuits[2] ..	50	10	3	29	8
Protene Training Biscuits ..	50	20	2	22	6
Protene Luncheon Biscuits ..	40	26	2	21	11
Protene Oatmeal Biscuits ..	45	25	2	23	5
Protene Fancy Biscuits (Diabetic)[2]	40	16	2	36	6
Protene Victoria Biscuits ..	30	37	2	20	11
Protene Sponge Cakes	25	56	1	—	18
Protene Salt Sticks	35	40	3	18	4
Protene Rusks	30	42	2	18	8
Protene Diabetic Rusks[2]	50	16	2	27	5
Protene Sponge Rusks	25	59	1	—	15

[1] This non-nitrogenous matter is not convertible into sugar.
[2] Products suitable in diabetes.

[2] See Achard and Weil, *Archiv. de Méd. Expér.*, x. 816, 1898, and Von Noorden, *op. cit.*, p. 454.

[3] See Hale White and Grube, *Zeit. f. Klin. Med.*, xxvi. 332, 1894.

which it is sometimes the principal carbohydrate present. Early, sour oranges, for example, contain only 2 to 3 per cent. of carbohydrate altogether, of which lævulose is the chief; and even sweet oranges have not more than 5 to 7 per cent.[1] For that reason their use may be permitted in most cases. Other fruits poor in carbohydrates are strawberries, gooseberries, apricots, and melons. In the form of compotes, sweetened with saccharin, they may be useful in some cases. Nuts, being practically devoid of carbohydrates other than cellulose, while rich in proteid and fat, may be allowed in almost every case.

Beverages in Diabetes.

The great thirst complained of by most diabetics demands the free use of beverages, and, fortunately, there is no reason to suppose that these do any harm, provided they be properly selected.

Much the same remarks apply here as in the case of fevers. Water is the best beverage, while the aerated waters should be indulged in more sparingly. Citric acid lemonade (10 grains to the pint, sweetened with ½ ounce of glycerine or a little saccharin) is also a pleasant thirst-quencher.

Tea and coffee may be allowed freely, and may be taken with diabetic milk, and sweetened with saccharin if preferred. Cocoa, though often forbidden, contains so little starch that it is not likely to do harm. Of course, pure cocoa should alone be selected. It also may be made with diabetic milk.

Alcoholic beverages are extremely useful, and one can rarely afford to dispense with them altogether. Alcohol is not merely in itself a valuable food in diabetes, acting both as a source of energy and as a sparer of proteid and fat, but it has also the further advantage of aiding greatly in the digestion of fat, of which, as has been so often insisted upon, every diabetic must freely partake. With the exception of malt liquors, liqueurs, and sweet wines, almost any form of alcoholic drink may be allowed. In cases where a very stringent diet is being enforced, recourse may be had to one or other of the sugar-free alcoholic drinks, a list of which has been given elsewhere (see footnote, p. 374). If the patient is gouty as well as diabetic, alcohol is better avoided.

Arrangement of Meals in Diabetes.

As diabetics usually suffer considerably from hunger, it is well to make the meals rather frequent.

[1] Kraus, *Zeit. f. Diät und Physik. Therapie*, p. 69, 1898.

Where a limited quantity of carbohydrate is allowed, it will be found convenient to adopt the suggestion put forward by Von Noorden, and arrange that each meal shall consist of one principal dish and an 'extra' in which the allowance of carbohydrate is contained. For example, in a severe case in which 2 ounces of bread and 2 ounces of potato are being allowed, the diet may be made up of the following constituents:

Meat	4 oz.
Bacon	2 ,,
Fish	2 ,,
Butter	6 ,,
Green vegetables	2 ,,
Eggs	4
Diabetic milk	2 pints.
Bread	2 oz.
Potatoes	2 ,,

Divided into meals, this would work out as follows:

Breakfast.

Chief dish: Bacon and a scrambled egg.
Extra: 1 oz. of bread, toasted with plenty of butter.
Tea with diabetic milk and saccharin.

11 a.m.

½ pint of diabetic milk.

Dinner.

Chief dishes: Meat (4 oz.), green vegetables and butter. Custard pudding, made of diabetic milk and 2 eggs.
Extra: Potatoes (2 oz.) and plenty of butter.
Water, spirit and water, or some dry wine.

Tea.

An egg; bread (1 oz.), plenty of butter.
Tea or coffee with diabetic milk and saccharin.

Supper.

Fish (2 oz.) with butter sauce.
1 pint of diabetic milk.

This diet contains about 85 grammes of proteid and 225 grammes of fat, not reckoning the carbohydrate, and has an energy-value of about 2,500 Calories.

By the use of some alcoholic drink at dinner and supper the value of the diet could easily be raised to 3,000 Calories, and upon this most cases will be found to gain weight.

In milder cases, for which more proteid is advisable, one can easily double the quantity of meat or fish, and the proportion of fat can be raised by the use of thick cream in tea, and its addition to mashed potatoes.

In cases in which a strict diet is being enforced, one can replace

the bread and potatoes by an extra allowance of milk and eggs and a more liberal use of alcohol.

In mild cases in which there is a considerable tolerance for carbohydrates, the quantity of fat in the diet can be considerably reduced.

It need hardly be said that the above diet is merely given as a sample; its proteid and fat containing ingredients may be varied very greatly according to the taste of the patient. It will be found, however, I think, to be well suited for routine hospital use.

Even in mild cases with a considerable tolerance for carbohydrates, Von Noorden recommends that the patient should be subjected at intervals of a year or so to a short course of very strict diet. He believes that in this way the power of the cells to assimilate carbohydrate may be conserved.

If coma threatens or has set in, it is best to abandon the strict diet, and to feed the patient mainly on milk, with a liberal use of alcohol.

It will be found a great advantage to begin the treatment of all cases of diabetes either in hospital or in a Nursing Home. The patient is then under strict supervision, and it is much easier to determine the exact nature of the case with which one has to deal. In addition to this, the discipline to which the patient is subjected has a wholesome influence upon him, and serves to educate him in methods of dieting himself when he returns to his ordinary life.

It only remains to point out that a dietary suitable for diabetics is, from the fact of its consisting mainly of animal food and fat, necessarily an expensive one, and this will be found to be a great obstacle to the proper treatment of diabetes amongst the poor. In many cases there is room here for charitable aid in enabling the patient to get abundance of such articles as butter, cream, and meat, without which proper treatment of the case is impossible.

CHAPTER XXVIII

THE PRINCIPLES OF FEEDING IN DISEASE (*continued*)

THE DIETETIC TREATMENT OF OBESITY.

THE occurrence of obesity is almost invariably an indication of a disproportion between the intake of potential energy in the form of food and the output of actual energy in the form of work. Sometimes the fault lies in an unduly large income, sometimes in too small an expenditure; not unfrequently both factors co-operate. There would seem, however, to be another, but very limited, group of cases, in which, owing to some inherent lack of vital power in the cells of the body, fat is able to accumulate even in the absence of any excessive intake of food. This may explain some of the cases in which patients become fat even although they are very moderate eaters. There is reason to believe, however, that this is a very rare event, and that in the majority of cases in which it is alleged to occur, the patient is really the victim of self-deception.[1]

It is obvious from these considerations that the proper treatment of obesity must consist either in a reduction in the total number of Calories of energy supplied in the food, or in an increase in the output of energy in the form of work, or in a combination of these methods.

An increased expenditure can be achieved by the use of suitable muscular exercises, but that method of treatment does not concern us here, and we may now direct our attention to the best means of diminishing the intake of energy in the form of food. And first one may ask, **Which chemical ingredient of the food is it most important to reduce**—the proteids, carbohydrates, or fats? Physiological investigation has shown that all of these ingredients *may* serve as sources of fat in the body if consumed in excess, but the risk of

[1] See Hirschfeld, 'Ueber den Nahrungsbedarf der Fettleibigen,' *Berliner Klinik*, April, 1898, Hft. 130; also Hoffmann, Leyden's Handbuch der Ernährungstherapie, p. 540, and Von Noorden, 'Die Fettsucht,' p. 24; Vienna, 1900.

proteids being converted into fat seems to be very small. As regards the relative dangers of an excess of carbohydrates or fats in the food, classical authorities on the subject are not altogether agreed, and, as we shall see immediately, schemes of diet for the obese have been drawn up, in some of which the carbohydrates have been specially restricted, while others are characterized by a limitation of fats.

The progress of research into metabolism in obesity, however, has shown that the question is, after all, and as far as the mere storage of fat is concerned, one of indifference. The only essential point is to reduce the total number of Calories supplied in the form of food, and whether this should be accomplished by limiting the carbohydrates or the fats, or both, is purely a matter of convenience, and one which must be decided chiefly by the tastes and habits of each individual patient.[1]

The next problem which presents itself, then, is, **To what extent should the total number of Calories in the diet be reduced?** Here, again, no hard-and-fast rule can be laid down. In some cases, such as in the very young, in whom probably a marked congenital tendency to the disease exists, it is difficult to keep the undue formation of fat in check at all. In others, such as the very old, it is probably unwise even to make the attempt, while in particular instances—for example, those in which the chief deposit of fat is in the abdomen—treatment is always peculiarly difficult. In an average case, however, such as is most commonly met with in the later periods of middle life, one must be guided mainly by the degree to which the obesity has developed, and in judging of this it is always better to go by the general appearance of the patient rather than by tables of height and weight.

Following the teaching of Von Noorden, and assuming that an average man of this age requires to be supplied with from 2,500 to 3,000 Calories of energy daily to meet his current expenditure in heat and work, one may divide cases into three groups:

1. Those in which it is merely necessary to reduce the diet by one-fifth, which means the supply of 2,000 Calories. This can best be done by cutting out sugar from the diet, by reducing the supply of fat and cereals, and by restricting the consumption of alcohol.

This plan is only likely to be successful if it can be combined with a free use of muscular exercise, and in any case the loss of weight under it can only be very slow.

2. In severer cases the diet may be reduced two-fifths, which means supplying only 1,500 Calories. Here it will be necessary to still

[1] See Von Noorden, *op. cit.*

further reduce the amount of fat in the diet, and to limit the consumption of bread; and in this case also the loss of weight is apt to be slow, unless the patient can at the same time take at least a moderate amount of active exercise. Von Noorden states that he prefers this scheme to any other, because, while it usually gives good results, it is never attended by any disagreeable consequences. He specially recommends it—

(1) In patients who are being treated at home, and are continuing to follow their usual occupation.

(2) In patients who can go into the country, and take a moderate amount of exercise without requiring medical supervision.

(3) In those for whom, owing to the presence of visceral complications, a rapid 'cure' might be dangerous.

(4) As the habitual diet in advanced cases in which periods of greater restriction are being observed.

3. The third degree of diet is that in which the total Calories supplied are reduced three-fifths—*i.e.*, to about 1,000 to 1,500 per day.

This group includes all the classical 'systems' of diet for obesity, as is shown by the following table:

System.	*Proteid. Grammes.*	*Carbohydrate. Grammes.*	*Fat. Grammes.*	*Calories.*
Banting	172	81	8	1,100
Oertel (maximum) ..	170	120	45	1,600
,, (minimum) ..	156	75	25	1,180
Ebstein	102	47	85	1,300
Hirschfeld (maximum)	139	67	65	1,400
,, (minimum)	100	50	41	1,000
Von Noorden	155	112	28	1,366

Some of these demand a word of description.

Banting System.—This scheme of diet was first popularized by the writer whose name it bears,[1] although it had previously been recommended in France by Léon.

Banting suffered from an extreme degree of obesity, so great, he tells us, as to render him unable to tie his own shoe, and to compel him to go downstairs backwards. Having consulted various physicians without success, and having tried the effects of violent rowing exercise and a course of Turkish baths, he was finally advised by an aural surgeon, Dr. Harvey, to abstain from bread, milk, butter, sugar, and potatoes, 'which had hitherto been the main

[1] See 'A Letter on Corpulence addressed to the Public,' by William Banting; London, 1863.

and, as he thought, innocent elements of his existence,' and to adopt instead the following diet:

Breakfast.

4 to 5 ounces of beef, mutton, kidneys, broiled fish, bacon, or any cold meat except pork; a large cup of plain tea, and a little biscuit or 1 ounce of toast.

Dinner.

5 to 6 ounces of any lean meat or fish, any vegetable except potatoes, 1 ounce of dry toast, some fruit out of a pudding, any kind of poultry or game, and 2 to 3 glasses of good claret, sherry or madeira.

Tea.

2 to 3 ounces of fruit, a rusk or two, and a cup of plain tea.

Supper.

3 to 4 ounces of meat or fish as at dinner, and a glass or two of claret.

For a 'night-cap' he was allowed a tumbler of 'grog' without sugar, or a glass or two of claret or sherry.

On this regimen Banting lost 35 pounds of weight in thirty-eight weeks, which is not surprising, considering that his diet hitherto had consisted of bread-and-milk for breakfast, or a cup of tea with plenty of sugar and milk, and buttered toast; meat, beer, much bread (of which he was always very fond), and pastry, for dinner; a tea of the same composition as breakfast, and a fruit tart or bread-and-milk for supper. He found sugar the most fattening of all foods, 5 ounces of it in a week causing his weight to rise 1 pound; and he calls milk, sugar, beer, and butter 'human beans,' because they have the same effect in the human subject that beans have in the case of the horse, and he regards these articles as 'the most insidious enemy an elderly man with a tendency to corpulency can possess, though eminently friendly to youth.' He adds: 'I can conscientiously assert that I never lived so well as under the new plan of dietary.'

It will be observed that the chief chemical characteristic of the Banting system is the great predominance of proteids in the diet, and it has been asserted, though with only a limited degree of truth, that owing to this fact one is more likely to insure a loss of body fat alone on it, and to prevent any inroads into the muscular tissues, than by any other plan.[1]

Be this as it may, the system has certainly the advantage of simplicity and of being easily regulated, and on this account it is likely to retain its popularity. It should be pointed out, however,

[1] For a discussion of this subject see Dapper, *Zeit. f. Klin. Med.*, xxiii. 113, 1893, and Von Noorden, *op. cit.*

that the large excretion of nitrogen which such a diet entails is apt to throw a severe strain upon the kidneys, and for that reason it is well always to investigate the state of these organs before embarking upon the treatment.

The chief characteristic of **Oertel's system**,[1] which has been largely popularized in Germany, though with some slight modification, by Schweninger, is that he restricts the consumption of fat more than that of carbohydrates, and at the same time lays great stress on limiting the amount of fluid in the diet. To the discussion of the latter point we shall return later, but at present the following may be taken as a type of his system. It is adapted, of course, to German habits:

First Breakfast.

1¼ ounces of white bread, 2 eggs, a large teacupful of coffee with 1 ounce of milk and 1 lump of sugar, and (in some cases) ½ ounce butter.

Second Breakfast.

2 ounces of lean meat, ⅞ ounce of coarse bread, 3½ ounces of light wine or clear soup.

Dinner.

5¼ ounces of roast beef with salad or green vegetables, 3½ ounces of pudding and fruit, a tumblerful of light wine, and (in some cases) 1 ounce of bread.

Afternoon.

A small cup of coffee as at breakfast.

Supper.

¾ ounce of caviare, 5¼ ounces of chicken or game, ½ ounce of cheese, ⅞ ounce of coarse bread, a tumblerful of water or light wine.

Ebstein[2] modified Banting's diet by increasing the proportion of fat and giving less proteid, as follows:

Breakfast.

A large cup of tea without milk or sugar, 2 ounces of bread with plenty of butter.

Dinner.

Soup, 4½ to 5½ ounces of meat with fat sauce, green vegetables, fresh fruit, 2 to 3 glasses of light wine.

Afternoon.

Tea as at breakfast.

Supper.

Tea, one egg, fat roast meat or ham, smoked fish, about 1 ounce of bread with plenty of butter, a little cheese, and fresh fruit.

Ebstein gives the following summary of his plan: 'The permission to enjoy certain succulent things, always, of course, in moderation,

[1] Oertel, 'Twentieth Century Practice,' ii. 625.

[2] 'Corpulence, and its Treatment on Physiological Principles' (translated from sixth German edition); Wiesbaden and London, 1884.

as, for instance, salmon, pâté-de-foie-gras, and such-like delicacies, reconciles the corpulent gourmet to his other sacrifices. These consist in the exclusion of the carbohydrates. Sugars, sweets of all kinds, potatoes in every form, I unconditionally forbid. The quantity of bread is limited at most to 3 or 3½ ounces a day, and of vegetables I allow asparagus, spinach, the various kinds of cabbage, and the legumes. Of meats I exclude none, and the fat in the flesh I do not wish to be avoided, but rather sought after. I permit bacon-fat, roast pork and mutton, and kidney-fat, and when no other fat is at hand I recommend marrow to be added to the soups. I allow the sauces as well as the vegetables to be made juicy, as did Hippocrates, only for his sesam-oil I substitute butter.'

Hirschfeld's diet[1] resembles that of Ebstein very closely:

Breakfast.

2 ounces of bread, and coffee without sugar or milk.

Forenoon.

2 eggs.

Dinner.

Soup with 2 ounces of rice (weighed uncooked), 8 ounces of lean meat boiled or roasted with a little fat.

Afternoon.

Black coffee.

Supper.

2 ounces of cream cheese, 4 ounces of bread, ½ ounce of butter.

Von Noorden[2] gives a large number of small meals, and restricts fats more than carbohydrates:

8 a.m.: 3 ounces of cold lean meat, 1 ounce of bread, a cup of tea or coffee with a spoonful of milk, but no sugar.
10 a.m.: 1 egg
Noon: A cup of strong soup without fat.
1 p.m.: A small plate of clear soup (à la Julienne or à la jardinière), 5 ounces of lean meat or fish, 3½ ounces of potatoes, green vegetables, 3½ ounces of fresh fruit.
3 p.m.: A cup of black coffee.
4 p.m.: 7 ounces of fresh fruit.
6 p.m.: A glass of skimmed milk.
8 p.m.: 4½ ounces of cold lean meat with pickles, 1 ounce of Graham bread, 2 to 3 spoonfuls of fruit cooked without sugar.

He also allows two glasses of wine a day.

It will be observed that all of these systems, seeing that they supply at least 1,000 Calories less than the number requisite to meet the outgoings of the body, must be regarded as **starvation methods of**

[1] 'Beiträge zur Ernährungslehre des Menschen,' *Virchow's Archiv.*, cxiv. 301, 1888; and 'Ueber den Nahrungsbedarf der Fettleibigen,' *Berliner Klinik*, Hft. 130, 1899.
[2] *Op. cit.*, p. 122.

treatment. For this reason it is never safe to carry them on for more than a few weeks at a time, during which the patient must be under strict supervision, and any symptoms of weakness or heart failure carefully watched for.

As regards the relative advantages of the different methods, a good deal of difference of opinion exists, and some patients will be found to prefer one plan, others another.

Ebstein specially recommended the inclusion of a considerable amount of fat in the diet, on the ground that, while it does not tend to the production of fat more than its equivalent of carbohydrate, it has a greater 'satisfying' power, and tends to allay feelings of hunger. It may be doubted, however, as Von Noorden has pointed out, whether this is really true of such quantities of fat as it is safe to allow, while, on the other hand, the greater bulk of carbohydrate food certainly tends to produce a feeling of satisfaction.

The point, however, is really one of indifference. Some patients stand a limitation of fat better than that of carbohydrates, whereas in the case of others the reverse holds good, but as long as the total number of Calories in the diet is kept low fat must inevitably continue to be lost from the body.

Whether or not it is advisable to restrict the amount of fluids in the diet, and if so to what extent, we shall proceed to discuss immediately.

On the Use of Particular Articles of Food in Obesity.

In drawing up a scheme of diet for the obese, it is well to avoid too great variety, for that always tends to increase appetite. For the same reason, all spices, condiments, and other articles that increase the desire for food, must be used very sparingly.

The following list of the Calorie value of some of the commoner articles of food may be of assistance in enabling one to arrive at some idea of their relative suitability as articles of diet for the corpulent:

Article.	*Calories.*
2 ounces of cheese	224
1 ounce of butter (enough to cover three or four slices of bread)	208
A helping of cooked lean meat (4 ounces)	196
A tumblerful of milk	140
A moderately thick slice of bread (2 ounces)	138
,, ,, ,, and butter	208
A heaped dessert-spoonful of milk pudding	110
One egg	70
One medium-sized potato (2 ounces)	45
An ordinary lump of sugar	16

It is well to avoid the use of sugar altogether, and to employ saccharin as a sweetener instead. Visible fat should be removed from meat, and the richer meats, such as pork, goose, etc., and the fatter fishes, such as mackerel, eel and salmon, interdicted. Milk and its products should only be used in moderation, and puddings must be unconditionally forbidden. Bread, also, is a very dangerous food, but as it can hardly be dispensed with altogether, it should only be allowed in weighed quantities. It is well, too, to select the coarsest sorts of bread, which contain much indigestible bran, such as Graham bread; for a given bulk of these yields much less nutriment to the body than an equal weight of fine bread. Potatoes, as the table shows, are not nearly so dangerous as bread, and may often be allowed in moderation. It is better to avoid the other roots and tubers, but green vegetables and mushrooms may be freely permitted, and their great bulk has the advantage of producing a feeling of satisfaction. Dried fruits must be strictly forbidden, but fresh fruit may be allowed in moderation, and, if necessary, may be stewed and sweetened with saccharin. All made dishes, thick soups, sauces and pastry must be cut out of the menu, as they are subtle vehicles for the conveyance of much fat and starch into the body.

The **arrangement of the meals** must be regulated to a large extent by the habits of the patient. Where i is feasible, most authorities seem to prefer that they should be small and frequent, as the total amount of food consumed is thus more easily kept under control.

Beverages in Obesity.

The first question to be settled regarding the use of beverages in obesity is whether or not it is important **to diminish the total amount of fluid** in the diet in that disease. The restriction of fluids was first advocated by a French military surgeon—Dancel—in a book published in 1863.[1] He had observed the influence of water and watery fluids in producing abdominal development in the horse, and he made reduction of fluids one of the main principles in the regimen which he drew up for corpulency. The principle was subsequently adopted by Oertel and Von Schweninger, and attained through their advocacy a very considerable degree of popularity.

Exact observation,[2] however, has now shown that the influence which the amount of water in the diet exerts upon the production or loss of fat in the body is very small in amount and uncertain in

[1] See also *Bull. de Thérap.*, vol. lxvii. p. 44, 1864.
[2] Dennig, *Zeit. f. Diät. und Physik. Therap.*, ii. 292, 1899.

degree, and that, as a matter of fact, fat people are less affected by a restriction of fluids than are lean.

Dancel restricted the intake of fluids to 7 to 14 ounces per day. Oertel allowed a daily maximum of 2¼ pints, and Von Schweninger of about 3 pints, but the latter made a strong point of fluids not being taken along with solids, but rather between meals.

The opinion of most authorities at the present time[1] seems to be that the restriction of fluids has, at best, only an indirect influence. In the case of some patients the interdiction of fluids at meals interferes with appetite, and so results in less solid food being consumed. In such cases the method may be of value, but where no such result ensues, the loss of weight which results is only temporary, and due to a diminution of the body fluids. It is probable, too, as Yorke Davies has pointed out,[2] that one reason why restriction of fluids has given better results on the Continent than one sees in this country is, that in Germany, at least, restriction of fluids is very often synonymous with restriction of beer.

The whole question, indeed, is to be regarded as one affecting the *technique* of feeding rather than the physiological principles upon which the dietetic treatment of obesity is founded.[3] Von Noorden concludes that restriction of fluids should only be insisted upon when the following indications are present:

1. *Weakness of circulation.* A dry diet is advisable here for the sake of the heart, apart altogether from the obesity.

2. *At the commencement of many 'cures.'* Here the initial loss of weight which the restriction of fluids brings about is calculated to make a great mental impression on the patient.

3. *In cases where the restriction results in a diminished appetite for fat-forming foods.*

4. *Where sweat secretion is excessive.* He considers that the total amount of fluid allowed should not be reduced below 2⅛ pints per day.

Where a Banting or any other very nitrogenous diet is being adopted, the restriction of fluids is to be avoided, as being opposed to the free elimination of the products of nitrogenous waste.

Of the different sorts of beverages in common use, water and the saline mineral and table waters may be regarded as harmless; but the sweetened effervescing waters, such as lemonade, should be

[1] See a discussion on obesity reported in the *Verhandl. d. 4 ten. Cong. f. Inn. Med.*, 1885.
[2] 'Foods for the Fat,' p. 26.
[3] See Von Noorden, *op. cit.*, p. 124 *et seq.*

avoided. Tea and coffee may be freely permitted, if taken with little milk and no sugar. Cocoa is often forbidden, but the amount of nutriment which an ordinary cupful of it contains is so small as to be hardly appreciable. In many people, also, it has the advantage of lessening the appetite for solid food.

Alcoholic beverages should be avoided as far as possible, for alcohol is, as we have seen, a direct sparer of fat. If a small allowance is indicated on other grounds—*e.g.*, feebleness of heart—a dry natural wine should be selected, or its alcoholic equivalent of well-matured spirit freely diluted with water. All strong and sweet wines, liqueurs and malt liquors should be interdicted.

Fattening Diet.

In the previous section we have dealt with the dietetic methods of reducing fat. We have now got to consider the means at our disposal for increasing it.

Generally speaking, any excess of food which is supplied to the body beyond the amount required to meet the current outgoings of energy in the form of heat and work will be stored up in the form of fat. This is perhaps not absolutely true. One does seem to meet with cases in which, owing probably to some failure of assimilative power, it is found to be very difficult to achieve the laying on of fat, even although a considerable surplus of food is supplied. Generally speaking, however, one may say that in order to fatten the body one has merely to insure the supply of an excess of food.

It will be obvious that one important means of bringing about such a surplus of income over expenditure is to diminish the outgoings of energy from the body. For this reason, rest, more or less complete, is always an important aid in cases in which one wishes to fatten.

As regards the constituents of the food which are most important in respect of fattening properties, it may be said that fat itself, owing to the ease with which it can be stored, takes the first place. It has been calculated by Rubner that 100 parts of fat, 248 of carbohydrate, and 313 of proteid, are equivalent in fat-forming power. Whether all forms of fat are equally valuable in this respect must be left undecided, but it is probable that some fats produce a more stable kind of adipose tissue than others.[1]

When one comes to the actual construction of a fattening dietary, however, due attention must be paid to the powers of the digestive organs, and for that reason it is better to see that carbohydrates

[1] See Weir Mitchell, 'Fat and Blood,' p. 25.

and fats are *both* abundantly represented, rather than to trust to one or other of them alone. Munk is of opinion that, in order to insure the laying-on of fat, one should supply 90 to 100 grammes of fat, 100 to 110 of proteid, and about 500 of carbohydrate, daily.

The permanent enrichment of the body in proteid (practically in muscular tissue and blood) is very much more difficult of accomplishment than the mere deposition of a certain amount of fat. So great is the tendency for nitrogenous equilibrium to assert itself that it is almost impossible to bring about a storage of proteid in the body[1] unless (1) a considerable amount of muscular exercise is taken at the same time, or unless (2) there has been a previous wasting of the muscles, such as occurs during acute disease.

In the former case the bulk of the muscles exercised can, up to a certain limit, be increased; in the latter the normal muscular development can be again attained. The one process occurs during training, the other during convalescence. In both proteid is stored up.

In practice the storage of proteid can be accomplished, granted the presence of one or other of the above conditions, either by increasing the actual amount of proteid in the diet or by raising the proportion of proteid-sparers. Weight for weight carbohydrate is, it will be remembered, a more powerful proteid-sparer than fat; but here, again, in actually constructing the dietary it is better to avail one's self of both ingredients.[2]

Practically, then, it comes to this, that where one wishes to lay on fat only, one should increase the proportion of fat and carbohydrate in the food, laying, perhaps, greater stress on the former; but where one wishes to lay on proteid, the proportion of that ingredient in the food should be increased as well, and prominence given to the increase of carbohydrate rather than to that of fat.

A fattening diet is wanted in three chief sets of conditions: (1) In convalescence from acute illness; (2) in wasting diseases, such as phthisis; (3) in some nervous disorders, of which neurasthenia may be regarded as the type.

In **convalescence** one desires to make good the waste of proteid and fat which the preceding illness has entailed. Out of respect, however, to the debilitated digestive powers of such a patient, one must proceed with some caution. There is reason also to believe that the metabolic conditions of fever continue for a day or two after

[1] For a discussion of this subject see Rosenfeld, 'Die Bedingungen der Fleischmast,' *Berliner Klinik*, Hft. 127, 1899.

[2] See Wicke and Weiske, *Zeit. f. Physiolog. Chem.*, xxi. 42, 1895, and xxii. 137, 1896.

the temperature has fallen, and on that account some observers advocate the continuance of the fever diet for three days after the pyrexia has ceased. One can then begin to thicken the patient's beef-tea, soups, and milk with cereal flours, and to add other farinaceous foods to the diet. Many of the patent malted foods may be usefully employed here. The increase of proteid may be accomplished by the addition of pounded meat to soups in the form of purées, and one may gradually pass on to the administration of the more easily digested forms of animal food, such as chicken, fish, and eggs. Jellies are also agreeable to the convalescent, and, along with custard or light milk puddings, are pleasant forms of proteid-sparing food. The enrichment of the diet in fat may be conveniently deferred till later, and should be accomplished by the free use of cream, butter, bacon and suet, or, if these cannot be compassed in sufficient quantity, one may have recourse to cod-liver-oil (see also p. 517).

One of the simplest methods of enriching the diet in **wasting diseases** is by adding to it a certain quantity of milk. One has frequent opportunity in cases of phthisis of observing the good effects of adding 2 or 3 pints of milk to the ordinary diet. It can be taken both as a beverage with the usual food and also between meals.

Fat seems to be of special value in the diet of phthisis, and by the use of the more easily digested forms of it, such as butter, bacon, pork, salad-oil and cream, one has usually not much difficulty in persuading patients to take enough of it, even when, as is not unfrequently the case in phthisis, a considerable natural repugnance to fat exists. Smith[1] recommends that phthisical patients should take the following amount of fat daily:

As milk	2¼ ounces.
,, butter	2 ,,
,, bacon	2-4 ,,
In meat	1½ ,,
As salad-oil	1 ounce.
,, suet in puddings	¼ ,,
Cream *ad lib.*	

This supplies altogether about 6 ounces of carbon, and by means of carbohydrates the total quantity can easily be raised to 10 ounces.

When fever exists, care should be taken to supply the food chiefly in the apyrexial periods. For the use of forced feeding in wasting diseases, the reader is referred to p. 526.

The method of feeding up **neurasthenic patients** has become so

[1] *Lancet*, April 16, 1864.

widely known under the title of the Weir-Mitchell treatment that no special description of it is called for here.

In all cases in which a large amount of food is being administered, the use of alcohol, in some form or another, will often be found a great help. Especially is this the case when the diet is very rich in fat. The safest guide to its use is the state of the appetite and digestion. Where these are improved by its administration, it does good. The form to be selected is largely a matter of taste, but a sound red wine, such as burgundy, is perhaps most generally useful, or, if a malt liquor be preferred, good bottled stout.

The Dietetics of Gout.

Unfortunately, chemical pathology is not yet in a position to furnish us with very clear indications as to the best diet for the gouty. In spite of all the work which has been done upon the subject, we are still, it must be confessed, very much in the dark as to the relations of uric acid to general metabolism. It is becoming more and more clear, however, that, in mammals at least, uric acid is derived mainly, if not entirely, from the decomposition of nucleins either contained as such in the food, or produced by the disintegration of the body cells. Uric acid from the first of these sources, to follow the nomenclature of recent writers,[1] may be conveniently described as 'exogenous uric acid,' while the fraction produced in the body may be designated as 'endogenous.'

While the nucleins of the food are the main, they are not the exclusive, source of the exogenous uric acid. Part of it is also derived from such substances as caffeine. Further, the whole of the uric acid which the nucleins and caffeine of the food are capable of yielding does not appear as uric acid in the urine. Part of it is converted in the body into other forms, such as urea. The fraction so changed varies from one-quarter to one-half of the total possible yield, but the amount is very constant for different foods, and appears to vary but little in different individuals.

The chief fluctuations in the amount of uric acid in the urine can be explained by variations in the amount of uric-acid-yielders contained in the food; the endogenous fraction, on the other hand, seems to be remarkably fixed, but as to its exact seat and mode of formation, and the conditions which control it, we have still much to learn.

[1] See a very important paper by Burian and Schur ('Ueber die Stellung der Purin Körper im Menschlichen Stoffwechsel'), *Archiv. f. d. Ges. Physiolog.*, **lxxx.** 241, 1900.

It is obvious, then, that we have at hand an important means of regulating the amount of uric acid liberated in the body, namely, by controlling the amount of uric-acid-yielders in the food. Foods rich in nuclein will yield most uric acid, and should therefore be avoided in gout. Examples of such foods are found in all cellular organs, *e.g.*, the thymus, liver and spleen. Ordinary meat also yields a fair amount, but much less than the articles just named. Tea, coffee, cocoa, and meat-extracts are also potential sources of uric acid of considerable importance. On the other hand, most vegetable foods, and milk, eggs and cheese among animal products, yield no uric acid.

We have here, then, one clear dietetic indication. If one wishes to lessen the liberation of uric acid in the body, the diet to be recommended is one composed of vegetables, eggs and milk. Meat, and especially such articles as liver and sweetbreads, must be avoided; so also must soups and other preparations containing the extractives of meat, as well as tea, coffee and cocoa. It may be well to call particular attention to the fact that *it is not the amount of proteid in the food which is of importance.* Nor is there any reason to believe that animal proteid as such is capable of yielding uric acid any more than vegetable. It is the nucleins that matter, and these happen to be abundant in animal foods only, though even amongst these milk and eggs are free from them.

It must not be supposed, however, that this exhausts the whole question of the relation of diet to gout. Nothing is more certain than that a patient may still suffer from that disease, even although the substances capable of yielding uric acid are reduced in the diet to a minimum. For we have still the endogenous production of uric acid to deal with, and about the influence of diet on such production we know almost nothing. Nor does accumulated clinical experience afford as much help as one might expect, for the opinions of different writers on the subject, as so often happens, are exceedingly conflicting. On the whole, the belief seems to be gaining ground that quantity must be attended to quite as much as quality, and that the best diet for the gouty is a spare one, containing only a moderate amount of carbohydrate and fat, and in which not too much of the proteid is derived from animal sources. In the light of the above facts, it might be well to add that, so far as is compatible with healthy nutrition, the animal ingredients should consist mainly of milk and eggs.

This may appear a rather unsatisfactory conclusion, but the available evidence does not justify a more dogmatic pronouncement.

What he drinks is, to the gouty man, quite as important as what he eats. Tea, coffee and cocoa are certainly sources of uric acid, and may therefore require to be avoided. Experience also shows that the free consumption of alcohol is harmful, and, if possible, the patient should try to live without it. Too often, however, this is a counsel of perfection, and in that case a sound natural wine, which may be taken with some alkaline mineral water, is the best beverage to select. The stronger wines are dangerous, both on account of the large proportion of alcohol which they possess, and also because they are apt to contain sugar, which is prone to excite dyspepsia in the gouty, even if it has—a point which is still *sub judice*—no influence on the production of uric acid itself. It is the fashion to recommend whisky to gouty people, and to this course there can be no objection provided it be taken well diluted, and the quantity limited to 2 ounces a day. It is certainly a useful resource in cases in which the natural wines disagree.

On the whole, however, it must be admitted that there is no better beverage for gouty people than plain water, and they should be encouraged to drink largely of it, as an admirable aid to the elimination of nitrogenous waste.

GRAVEL.

The rational indications in the treatment of gravel would appear to be two in number: (1) To diminish the amount of uric acid which the urine contains; (2) to increase its solubility.

The former of these indications can be fulfilled, as far as the exogenous fraction of the urinary acid is concerned, by a diminution of the amount of uric-acid-yielders in the diet. We have already seen what are the best foods to select for that purpose. As regards diminishing that part of the uric acid which is formed in the body itself, we are just as much at a loss as in the case of gout. Some authorities pin their faith to a diminution of the proteid-sparers—*i.e.* carbohydrates and fat—in the food. It is possible that this may favour the conversion of uric acid into urea, though it must be admitted that such a view is as yet very far from being proved. At all events, this plan has commended itself to such an experienced observer as Sir Henry Thompson.

He recommends[1] that the diet should consist of white fish, poultry, game, lean meat, unsweetened jellies, bread, cereals, pulses, green vegetables and apples, but no sweet fruits. A little butter may be

[1] 'Diseases of the Urinary Organs,' 8th edit., lecture xxv.

taken, and milk in moderation. The things to avoid are cream, eggs, cheese, pastry, pork and other fat meats, the fatter kinds of fish, suet, much milk or butter, and all substances containing sugar. He advises that farinaceous foods should be mixed with light broths instead of milk, and flavoured with some condiment, such as a pinch of curry or a morsel of chutney, instead of sugar.

On the other hand, Goodhart,[1] after mentioning the case of a patient who suffered from gravel when on a milk diet, but got quit of it on changing to meat and port wine, says: 'I have come to be certain that in the majority of cases of uric acidity it is not a question of diet at all!'

The second indication mentioned above—that of increasing the solubility of uric acid in the urine—can be accomplished by rendering the urine less acid. As Sir William Roberts has said,[2] the deposition of uric acid from an alkaline urine is a chemical impossibility. Now, we can certainly render the urine less acid by the free use of green vegetables and other foods containing alkaline salts of potash, but the same object can be accomplished so much more certainly and simply by the aid of drugs that the dietetic means at our disposal are hardly worth considering. The other factors concerned in keeping uric acid in solution are the presence of urea and mineral salts. An increase in these hinders the separation out of uric acid. For that reason it may be well that the diet should not be too poor in proteids, and that it should contain an abundance of common salt.

As regards the question of beverages in gravel, the same remarks apply as in the case of gout.

3. Diet in Disorders of the Stomach.

General Considerations.

Seeing that the essential rôle of the stomach is a mechanical rather than a truly digestive one, the physical form of the food must always be of more importance in dyspepsia than its chemical composition. In proof of this, one finds that so long as the stomach is able to pass the food on into the intestine absorption and nutrition go on without impairment, even although the digestive juices of the stomach itself are no longer present.[3] The first rule to be observed, therefore, in drawing up a dietary for disorders of the stomach, is to see that the

[1] An address on 'Acidity,' *Lancet*, January 6, 1900.
[2] Croonian Lectures, 1892.
[3] See Von Noorden, 'Ueber den Stoffwechsel der Magen Kranken und Seine Ansprüche an die Therapie,' *Berliner Klinik*, Hft. 55, 1893, and the same author, *Zeit. f. Klin. Med.*, xvii 137, 1890; also Moritz, *Münch. Med. Woch.*, No. 4, p. 75, 1893.

food is presented in such a form that the stomach has but little difficulty in driving it on into the duodenum. In practice this means that the food must be in a fine state of division, and should be carefully chewed.

The question of bulk must also be considered. The larger the mass of the food, the greater is the muscular labour imposed on the stomach. It is probably on this account that animal foods are, as a class, less troublesome to most dyspeptics than vegetable products. For the same reason, the meals in dyspepsia should be of small size, but taken at rather short intervals.

As regards the behaviour of the dyspeptic stomach to the different chemical ingredients of the food, great individual differences exist, and in no class of case is it more important to study the question of idiosyncrasy. In a majority of instances, however, one finds that fa' is more apt to give offence than any other constituent. This is particularly true of *cooked* fat, probably because in process of cooking fatty acids, acrolein, and other irritating substances, are apt to be liberated. On the other hand, butter and bacon-fat can usually be managed with but little difficulty.

We may now pass to the more detailed consideration of the dietetic treatment suitable in different forms of gastric disorder, leaving the discussion of some further general principles until we come to speak of 'functional' dyspepsias. In handling the subject it will be well to take up first those diseases of the stomach which are accompanied by definite organic change, and afterwards to consider the so-called 'functional' disorders in one group. Such an arrangement is admittedly unscientific, but it has the advantage of practical convenience, and our knowledge does not at present admit of any more satisfactory system of classification.

Gastric Ulcer.

Ever since Cruveilhier clearly enunciated it, the principle has been accepted by all writers that rest for the organ is the point chiefly to be aimed at in arranging a diet for cases of gastric ulcer, and rest may be taken to mean the protection of the mucous membrane from both mechanical and chemical irritants.

In very severe cases, and especially if there has been recent bleeding, rest must be absolute. This is accomplished by cutting off all nourishment by the mouth, and feeding the patient exclusively per rectum. Many cases have recently been treated in this way for periods of even twenty days at a time, and with the greatest

advantage to the patient.[1] The details of such treatment will be considered in the last chapter.

After a week or ten days of rectal feeding, if all pain and vomiting have ceased, and in less severe cases from the outset, one can begin to feel his way in giving food by the mouth. At first the diet must be strictly fluid, consisting of milk, diluted with lime or barley water, or peptonized, given in small quantities and at the body temperature at short intervals of time. Small feeds of beef-tea may be given occasionally as a change.

After another week, if all is going well, one may advance to semi-fluid diet, the milk and beef-tea being thickened with a little corn-flour, or arrowroot, or fine oat flour. Some of the patent predigested cereal foods are useful at this stage. The Leube-Rosenthal Meat Solution is also well borne as a rule, or one may substitute for it well-made 'whole beef-tea,' or a little of one of the patent proteid foods (Nutrose, Plasmon, etc.) may be given stirred into clear broth.

After the lapse of another week one may add a little stale bread and butter, sweetbread or white fish, potato purée and custard, and gradually advance to underdone mutton, milk pudding, spinach and cauliflower, and from this to ordinary plain unirritating food (see Chronic Gastritis).

Any recrudescence of symptoms must be the signal for immediately retracing one's steps and reducing the diet, and even when convalescence is fairly established the patient must be careful for a long time to avoid all irritating and indigestible forms of food.

Acute and Chronic Gastritis.

The dietetic treatment of **acute gastritis** must proceed on the same lines as that of gastric ulcer. The affection, however, being usually of but short duration, rectal feeding is rarely required, all that is necessary being to withhold all food until vomiting has ceased, thirst being meanwhile relieved by sips of hot water or by sucking fragments of ice. If there is great depression, a little champagne may be given, preferably diluted with seltzer-water.

After the acute symptoms have subsided, the patient may gradually return to ordinary diet by the same stages as in gastric ulcer, but the steps of advance may usually be separated by periods of one or two days only, instead of by a week.

In the treatment of **chronic gastritis**, it is important to avoid the

[1] See 'Traitement de certaines Maladies de l'Estomac par la Cure de Repos absolu et prolongé avec Alimentation rectale exclusive,' Dr. A. P. Gros; Paris: Baillière et Fils, 1898.

use of anything that may irritate the gastric mucous membrane or excite a secretion of mucus. Mustard, pepper, spices, and condiments of all sorts, must be forbidden. Alcohol also should be avoided, especially in concentrated forms, for many of these cases are really brought on and maintained by the drinking of neat spirits. Coffee is apt to be injurious owing to the oily substances which it contains, but weak tea may usually be permitted.

Sugar is a very unsuitable food in these cases, more especially cane-sugar (see p. 267), for it excites a large secretion of mucus. Grape and milk sugar are much less likely to do harm. All cooked fats, pastry, sauces, and fat meats should be excluded from the dietary; but butter is usually well borne if taken in moderation, and some patients can even manage bacon.

Bread should only be taken thoroughly toasted, and potatoes in the form of purée. Cauliflower and spinach are the most suitable of vegetables. The food should be finely divided, eaten slowly, and but little taken at one meal. At the same time it is important to avoid mere 'slops.'

The following may be regarded as a typical diet schedule for an average case:

Breakfast.

Lightly-cooked eggs, white fish (boiled), a little crisp bacon (not too fat), fowl, game; dry toast with a little butter; a small cup of weak tea with milk, but no sugar.

Luncheon.

Lean mutton, underdone, or underdone roast beef, white fish, etc., as at breakfast; mashed potato and a little spinach or cauliflower; dry toast; custard pudding or unsweetened jelly; a glass of alkaline mineral water, with perhaps a little claret or hock.

Tea.

A small cup of tea, as at breakfast; a slice of crisp toast and butter, or a plain biscuit or rusk.

Dinner.

A very little clear soup free from fat; white fish, without sauce; meat as at luncheon or breakfast, or a little sweetbread or tripe; vegetables as at lunch; custard, jelly, or fruit stewed without sugar, and free from skins or stones, or a little plain milk pudding; a lith or two of orange at dessert, the juice only being swallowed and no sugar taken; dry toast; a glass or two of good claret or burgundy and some mineral water; no coffee.

It may be well to point out that many cases of alcoholic gastritis stand midway, as regards the urgency of their symptoms, between the acute and chronic forms of the disease, and in such cases confinement to bed on a strict milk diet is often the most successful method of treatment.

Dilatation of the Stomach.

The kind of diet suitable for cases of dilated stomach must obviously depend upon the degree of pyloric obstruction. In all cases, however, certain general principles must be observed: (1) It is important to avoid overburdening the weakened organ with any considerable mass of food at one time. The meals, therefore, should be small. (2) Substances must be excluded from the diet which are capable of supplying pabulum to the yeasts and sarcinæ so often found in the dilated viscus. The food should, therefore, be unfermentable. (3) Attention should be concentrated on rendering the food easily passed on into the intestine, rather than upon any attempt to make it capable of absorption in the stomach itself. The reason for this is that, even under the most favourable circumstances, the stomach absorbs but little, and when it is much dilated the process is probably arrested altogether.[1] Food should, therefore, be given either in a fluid or semi-fluid form or in a state of very fine division. (4) It must be remembered that water is not absorbed by the stomach at all, and if the pyloric stenosis is complete the tissues may suffer from water starvation. In such cases it is necessary to supply the blood with fluids by another route than the mouth. (5) In all cases of dilatation of the stomach, periodic lavage of the organ is a great aid to successful feeding.

In *complete pyloric obstruction* the patient must be fed per rectum (Chapter XXIX.). An occasional saline enema, or the subcutaneous injection of salt solution, will be necessary to insure a due supply of fluids.

If the obstruction be *extreme, but not complete*, peptonized milk should be given in small and frequent feeds. The milk may be enriched by an unfermentable sugar, such as lactose, or by the addition of one of the concentrated proteid foods (Nutrose, Plasmon, etc.).

In cases of *dilatation with comparative freedom from pyloric obstruction* the diet may follow very much the lines already laid down for chronic gastritis, but even greater care must be exercised in the use of farinaceous substances and fats, and the food should be finely divided. It is better to avoid all effervescing beverages, as they tend unduly to inflate the stomach. A little hot water may be drunk immediately after meals, and also with advantage on going to bed and on first rising in the morning.

[1] See Klemperer, *Deut. Med. Woch.*, No. 9, 1889, and *Verhand. d. 8ten. Cong. f. Inn. Med.*, p. 271, 1889.

Functional Dyspepsias.

Under this heading one may group for convenience that large and heterogeneous class of cases in which digestion is performed painfully or with difficulty, but in which no organic change in the organs of digestion can be discovered. In some of these cases the chemistry of the stomach is at fault, but in many the basis of the condition would seem to consist rather in a hyperæsthesia of the stomach, an undue sensitiveness to normal irritants.

In treating them it is essential to keep one or two principles clearly before one's mind. (1) In many of these cases the patient's general nutrition requires to be considered rather than his mere gastric sensations. If the nervous system and blood can be raised to a proper level of health, the dyspeptic symptoms often disappear spontaneously. For this reason great harm may be done by too strict dieting. The tendency in such patients is to go on cutting off one article of food after another until a state of semi-starvation is induced, in which it is impossible for any organ in the body properly to perform its work. Instead of adopting this plan, it would be well if such people could be induced to follow the advice of King-Chambers, and add to the diet any article of food that had once been found to agree, rather than to cut out of it anything that had ever disagreed. (2) Mental and physical rest, preferably in bed, is a great and sometimes indispensable aid to treatment. It acts both by economizing vascular and nervous energy and by enabling nutrition to be efficiently carried out upon a minimum quantity of food, and therefore with the least amount of labour on the part of the digestive organs. (3) In no class of gastric disorders does the question of idiosyncrasy play a greater part than in this. Due regard must therefore always be paid to the inclinations of individual patients in arranging the diet-sheet.

In all cases of this class the same elementary dietetic rules must be observed as in other forms of digestive trouble. The food must be in a suitable physical form, all notoriously indigestible articles being avoided; the meals should be properly arranged, and chewing carefully performed. To these simple directions one need only add that good cooking and attractive presentation of the meals are here of the first importance.

As a general rule, the diet may run on much the same lines as that for chronic gastritis, but the avoidance of *chemical* irritants is not essential; indeed, in some cases they actually aid digestion by increasing appetite and the movements of the stomach walls.

For the same reason a glass or two of sound wine often helps the digestion of the larger meals. Where acidity is a prominent symptom it will generally be found that foods rich in proteid are best borne. The reason for this, no doubt, is that proteids are able to fix a large amount of hydrochloric acid, and so delay the appearance of free acidity. The diet should therefore contain a large proportion of animal food. Milk, being the most powerful acid-neutraliser of all foods,[1] is also indicated, and if guarded by the addition of lime-water is usually well borne.

On the other hand, foods rich in carbohydrate must be partaken of sparingly, as free acid appears in the stomach very early after their use, and the conversion of their starch by the saliva is interfered with. For this reason the addition of malt to farinaceous foods is often of great service in such cases.

Fat is often well digested by such patients, and there is physiological evidence to show that it tends to restrain the secretion of gastric juice (Pawlow).

If flatulence is much complained of, green vegetables and pulses should be avoided, and potatoes partaken of sparingly. The diet should be mainly an animal one, and fluids should be restricted, tea, in particular, being very harmful.

Diseases of the Intestines.

In **diarrhœa** the chief point to be aimed at in feeding is to select a diet which shall be unirritating, and shall leave as small an unabsorbed residue as possible. If the diarrhœa is very severe, it may be necessary to withhold all food for a day or two, nothing being given by the mouth but a little barley-water to quench thirst. When the symptoms have somewhat abated, and in milder cases from the outset, one can allow weak decoctions of cereal preparations, such as arrowroot, rice, cornflour, sago, etc., or one of the patent cereal foods. These should be given at the body temperature.

By-and-by one can begin to give milk, but tentatively and always safeguarded with a little lime-water. Raw-meat juice, alum-whey, egg-white solution, and the pulp of underdone beef are also useful; but all solutions containing the extractives of meat are best avoided.

If the patient is very thirsty, he may be allowed sips of cold tea or diluted red wine, or water flavoured with a little lemon-juice.

In the acute **diarrhœa of infancy** all milk must be stopped for at least twenty-four hours, and nothing given but egg-white solution

[1] See Schüle, *Zeit. f. Klin. Med.*, xxviii. 460 and xxix. 49; also Pawlow's 'Die Arbeit der Verdauungsdrüsen.'

(the white of one egg to ½ pint of water, flavoured with a little milk-sugar). Raw-meat juice and alum-whey are also very useful in such a case. When milk is recommenced, it should be given peptonized at first. The administration of salt solution, either per rectum or subcutaneously, will often tide over the crisis in an acute case.

In the treatment of **constipation** much can be accomplished by suitable diet. Food can increase peristalsis either by (1) mechanical or (2) chemical action.

Foods which leave a large amount of residue or 'ballast' in the intestine act in the former way. Generally speaking, all foods rich in cellulose belong to this class, *e.g.*, oatmeal, green vegetables, wholemeal bread, and some fruits. All of these should therefore find a place in the diet. Water also acts in a large measure mechanically by increasing the fluidity of the intestinal secretion, but in part also its action may be reflex. It is best given cold the first thing in the morning. Fats and oils, too, act as mechanical lubricants, and sufferers from constipation should partake of all of them freely, especially if the motions are small and dry.

The chemical action of foods is usually brought about by the organic acids which they contain. It is probable, indeed, that foods rich in cellulose owe their laxative properties largely to the fact that they are very apt to undergo fermentation in the intestine, with the production of lactic, acetic, and other acids.

Fruits are, of course, the foods richest in organic acids, and should always be freely used in such cases. They may be taken either fresh or stewed, figs and prunes being perhaps the best forms to select.

Of beverages, cider has a decidedly laxative action, though it is apt to produce colic in many persons, and malt liquors sometimes act similarly. On the other hand, red wines are usually astringent, and so often is sherry. Milk is also a very constipating fluid.

4. Disorders of the Circulation.

The consideration of the dietetic treatment of cardiac disease follows naturally upon that of digestive disorders, for no two organs are in closer sympathy than the heart and the stomach, and by lightening the work of the latter one indirectly aids the former. When the heart's action is impaired, the diet should be easily digested and non-flatulent, and the food should be given in small quantities at a time at not too short intervals, and should be rather dry. The limitation of fats is also quite as important as in cases of dyspepsia, for there is reason to believe that fats are badly absorbed in cases of

severe cardiac disease.[1] Carbohydrates must also be used very sparingly, owing to their tendency to produce flatulence. Hence it is that the diet of cardiac disease must be pre-eminently nitrogenous in its nature. The object of all this is to prevent overdistension of the stomach, which is apt to be followed by embarrassment of the heart. In the main, therefore, the same principles must be attended to as in the dietetic treatment of dyspepsia.[2]

The value of a **dry diet** in cardiac disease has been specially insisted upon by several writers.[3] Its beneficial action is probably exercised in several ways: (1) In cardiac disease fluids are absorbed very slowly, and are therefore apt to interfere with digestion and produce flatulence; (2) if fluids are withheld, the blood tends to become more concentrated, and water then passes into it out of the tissues, and thus the absorption of dropsical effusions is aided;[4] (3) the sudden entrance of any considerable quantity of fluid into the circulation throws a mechanical strain upon the heart by increasing the amount of blood which has to be propelled round the circulation. Thus limitation of fluids lessens the work of the heart (see also p. 290).

In cardiac dropsy, therefore, and especially if complicated by obesity, the quantity of fluids allowed should be limited to about 20 ounces per day, and not more than 5 ounces should ever be taken at one time. If much thirst is experienced, it may be relieved by sucking a few acid drops.

The following is G. W. Balfour's scheme of diet for patients with weak hearts:[5]

Breakfast, 8.30.

About 1½ oz. of dry toast with butter, a lightly-cooked egg or a little white fish; 3 to 5 oz. of tea or coffee with cream and sugar.

Lunch or Dinner, 1.30 *to* 2 *o'clock* (*the principal meal of the day*).

Two courses only, fish and meat, fish and pudding, or meat and pudding. *Soups, pastry, pickles and cheese absolutely forbidden.* The most digestible forms

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[1] See Grassmann, *Zeit. f. Klin. Med.*, xv. 183, 1889.

[2] G. W. Balfour ('The Senile Heart,' p. 240) lays down the following dietetic rules for patients with weak hearts:

i. There must never be less than five hours between each meal
ii. No solid food is ever to be taken between meals.
iii. All those with weak hearts should have their principal meal in the middle of the day.
iv. All those with weak hearts should have their meals as dry as possible.

[3] See Oertel, Leyden's 'Handbuch der Ernährungstherapie, Bd. ii., p. 55 *et seq.*; also Cheadle, *Lancet*, pp. 758, 794, 838, 877, 1877; Dickinson, Clifford Allbutt's 'System of Medicine,' v. 690; and Balfour, 'The Senile Heart,' chap. x.

[4] Cheadle particularly insists upon the importance of limiting the intake of fluids in cases of ascites, even when due to cirrhosis (*Lancet*, April 14, 1900).

[5] *Op. cit.*, p. 246.

of meat or fish to be selected; one potato or a little spinach. Any form of simple milk pudding may be taken or a little fruit. During the meal 4 to 5 oz. of hot water may be sipped if desired.

Tea, 5 to 6 o'clock.

3 or 4 oz. of weak tea with cream and sugar, but *no solid food.*

Supper, about 7 o'clock.

Must always be a light meal. May consist of white fish and a potato, or toast with butter, or some milk pudding or bread-and-milk. 4 or 5 oz. of hot water may be taken at bedtime.

While some such diet as the above may be adopted with advantage by patients with weakness of the muscular substance of the heart, it must be remembered that in cases of **acute cardiac disease**, and often enough where there is severe impairment of compensation, and consequently great interference with digestion, it may be necessary to have recourse to fluid diet, milk or peptonized milk being given in small quantities at short intervals of time.

The dietetic treatment of **aneurism** requires a word of mention. Our object here must be to diminish the force of the heart and to increase the coagulability of the blood.

Valsalva claimed that he was able to do this by a process of starvation. He used only bread and water or pudding and water, giving as little as half a pound of pudding night and morning. His patients often became so weak that they were unable to sit up in bed. Some good observers have spoken highly of this method,[1] but for the most part it is now but rarely adopted.

Tuffnell's diet for aneurism is somewhat less severe, and can be followed out for longer periods. He allowed 4 ounces of bread-and-butter, 2 or 3 ounces of meat, 4 ounces of milk, and 3 or 4 ounces of claret, daily. Here again the chief characteristic of the diet is its extreme dryness.

The dietetic indications in high vascular tension will be dealt with in the following section.

5. Renal Disease.

In the dietetic treatment of renal disease the principles chiefly to be borne in mind are: (1) to diminish the amount of work thrown upon the kidneys; (2) to avoid all ingredients in the food which, during their excretion, are calculated to irritate the diseased organs.

1. As the kidneys are the chief route for the excretion of the products of nitrogenous waste, the former of these principles involves

[1] See King Chambers, 'Lectures, chiefly Clinical,' lecture xxiv.

that the diet should be not too rich in proteids,[1] and should, as far as possible, be free from nitrogenous extractive matters.

We shall see immediately, however, that as regards chronic renal disease, at any rate, the former of these indications may sometimes require to be overridden by more pressing considerations. The amount of salt in the food should also be diminished as far as possible, for the burden of excreting it falls entirely upon the kidneys.

2. Amongst the substances calculated to irritate the kidney in the process of their excretion are such articles as spices, mustard, pepper, curry, ginger, radishes and asparagus. Alcohol, especially in concentrated forms, is also strongly contra-indicated in most cases of renal disease for the same reason, and of non-alcoholic beverages ginger ale should be avoided, owing to the fact that it contains either ginger or capsicum or both.

In **acute renal disease** an exclusively milk diet is, by common consent, the best method of treatment. That this is not a mere general impression is proved by the fact that in such cases a milk diet is found to increase the elimination of urea and other solids, and to decrease the amount of albumin in the urine.[2]

The milk may be given either plain or, what is better, diluted with some alkaline mineral water, and if the patient tires of it kephir or butter-milk may be used as a partial substitute.

The beneficial effects of milk cannot be altogether due to the fact that it is poor in proteids. As a matter of fact, relative to its other constituents, milk contains a very considerable proportion of nitrogen. It is not improbable that its advantages are to be partly attributed to the chemical peculiarities of casein, and to the fact that on a milk diet intestinal putrefaction is reduced to a minimum. The large amount of water, too, which milk contains has a good effect in favouring elimination. The addition to the milk diet, in acute renal disease, of substances containing only carbohydrates and fats is open to no theoretical objection, and might perhaps be more extensively adopted in practice.

In **subacute nephritis** the prolonged nature of the complaint necessitates a more solid diet. The principle of keeping the proportion of proteid as low as possible must still, however, be maintained. The more nearly the case stands to the acute form the more

[1] The belief that a liberal supply of proteid is required in renal disease in order to make good the albumin excreted in the urine is baseless. Assuming an average excretion of ½ per cent. albumin, the daily loss would not amount to more than 8 grammes, and would be covered by the proteid contained in the whites of two eggs.

[2] See Ralfe, *Trans. of the Med. Soc.*, xvii. 251, 1894.

extensively should milk be used as the chief source of proteid, but in the more chronic forms of the disease other animal foods may be allowed in small quantity. It is the custom to select from these the white meats, such as fish, chicken and veal, as preferable to the dark meats. This preference is based upon the belief that the former contain less nitrogenous extractive matter than the latter. That this is true as a chemical fact has been denied by Von Noorden and others,[1] and recently the matter has been put to a practical test by Pabst.[2]

He compared the amount of albumin in the urine of patients with subacute nephritis (large pale kidney) on (1) milk diet, (2) a diet containing ½ pound of chicken or veal, (3) a diet containing a similar quantity of ordinary meat, with the following results:

AVERAGE DAILY EXCRETION OF ALBUMIN.

Diet.	First Case.		Second Case.
	First Experiment.	Second Experiment.	
Milk	14·5	15·1	12·9
White meat	13·0	12·7	12·1
Milk	12·7	11·4	13·4
Ordinary meat	12·9	12·4	13·1
Milk	12·0	10·9	12·4
Mixed diet	13·0	8·9	12·2

He concludes that the kind of diet had no appreciable or constant influence upon the composition of the urine or the amount of albumin which it contained.

It must be remembered, however, that the white meats, and especially fish, are, weight for weight, poorer in proteid than the others, and therefore if one wishes to keep the amount of nitrogenous matter in the diet low there may still be advantage in having recourse to them, although it must be admitted that the recent observations just quoted tend to show that the dark meats may not be so harmful as was supposed, provided they are used in moderation.[3] It is probable, too, that the same diet may not suit all patients equally well. Sparks and Mitchell Bruce,[4] in a case very similar to those of Pabst, certainly found that milk gave better results than anything

[1] See *Verhand. d. 17ten Cong. f. Inn. Med.*, 386, 1899, and Offer and Rosenquist, *Berlin. Klin. Woch.*, Nos. 43, 44, 1899.
[2] *Berlin. Klin. Woch.*, No. 25, 1900.
[3] See also Senator, *Berlin. Klin. Woch.*, No. 45, 1899.
[4] *Med.-Chir. Trans.*, lxii., p. 243, 1879; see also Prior, *Zeit. f. Klin. Med.*, xviii. 72, 1891.

else. One may therefore require to feel one's way in selecting the most suitable diet.

The non-nitrogenous constituents of the diet in subacute nephritis call for less consideration. Fats and carbohydrates may be freely allowed, but alcohol and all irritating substance should, as in all renal cases, be avoided.

In arranging the diet for cases of **chronic nephritis**, regard must not be paid too exclusively to the requirements of the kidney. Important as it is to reduce the nitrogenous waste matters in the urine as much as possible, this must not be done at the expense of other organs. The maintenance of a due degree of cardiac hypertrophy and increased vascular tension, which are essential to the occurrence of proper excretion in chronic renal disease, requires that the amount of proteid in the food should not be too rigidly limited. On the other hand, an undue increase of blood-pressure, which may be induced by a too highly nitrogenous diet, and especially, perhaps, by one which is rich in extractive matters, is itself a source of danger, as predisposing to arterial degeneration and to apoplexy.

It will be obvious from all this that the proper dietetic management of a case of chronic Bright's disease often requires careful steering. If there is too little proteid in the food, cardiac compensation may break down and uræmia result; if there is too much, the patient is exposed to all the risks and inconveniences of excessive vascular tension. For the former reason milk is not suited to constitute the sole source of proteid in the diet of such cases; for the latter the excessive use of meat is also to be deprecated. As a general rule, perhaps, one may say that the more the secreting tubules, as opposed to the glomeruli, are involved, the less proteid should the food contain; but for the majority of cases the most appropriate diet is that recommended for gout, *i.e.*, one which is only moderately rich in proteid, and that chiefly derived from vegetable sources, and from which soups and all preparations containing the extractives of meat are excluded. Finally, a word about **the use of fluids** in the more chronic forms of renal disease. It was laid down as a rule by Bamberger that in no form of kidney affection should fluids be restricted unless diarrhœa was present. Recently this dictum has been criticised by Von Noorden,[1] who states that if dropsy has occurred great benefit may be derived from limitation of fluids to 2½ pints daily, especially if there is cardiac dyspnœa and threatening heart failure. He says that long-continued observations by himself and his assistants have quite failed to show that the products of nitrogenous waste are not

[1] *Verhand. d. 17ten Cong. f. Inn. Med.*, p. 386, 1899.

well excreted under such a plan, and cites several cases in which it wrought great improvement. This view has been endorsed by Ewald. It must remain for further clinical experience to substantiate these conclusions, but in cases of high vascular tension, at all events, the sudden entrance of a considerable quantity of fluid into the circulation must always be apt to be injurious, and in such circumstances, whether the total daily supply of fluids be limited or not, it is wise to forbid the consumption of a large quantity at one time.

The habitual use of alcoholic beverages should, as in all forms of renal disease, be avoided as far as is practicable, unless they are imperatively indicated from the side of the heart.

CHAPTER XXIX

ARTIFICIAL AND PREDIGESTED FOODS AND ARTIFICIAL FEEDING

IN this chapter we shall describe some patent and artificial foods not yet dealt with, and consider the methods of administering food otherwise than by the mouth.

1. Artificial Foods.

The objects of artificial foods may be said to be either (1) to present a maximum of nourishment in a minimum of bulk, or (2) to enable one easily to enrich the diet in respect of certain of its chemical constituents.

In regard to the former of these objects, it is well to realize at the outset what **degree of concentration of food** is chemically possible. Let us take first the case of the **proteids**. Lean meat may be regarded as the type of a natural proteid food. It contains about one-fifth of its weight of that constituent, the rest being chiefly made up of water. If one drives off all the water from 5 ounces of meat, there will be left behind about an ounce of what is practically pure proteid. Now, this may be regarded as the maximum degree of concentration of which proteid food is capable. In other words, an ounce of any artificial proteid food can never represent more than 5 ounces of lean meat. A more concentrated proteid food than that is a chemical impossibility. One can realize from this the absurdity of such preparations as beef-lozenges. Even did these consist of pure proteid (which they never do), it would require 1 ounce of them at least to be equal in food value to 5 ounces of fresh meat, so that the amount of nutriment contained in one lozenge must be very small indeed.

Or take, again, the case of the **carbohydrates**. There is no form of carbohydrate food more concentrated than sugar. Any fluid or semi-fluid carbohydrate preparation must inevitably be of lower

nutritive value than sugar, for it contains more or less water, the food value of which is nil. Such preparations as malt-extracts, therefore, can never add to the diet as much carbohydrate as an equal weight of ordinary sugar.

The same is true of **fats**. No artificial preparation can have a higher food value than pure olive-oil, which contains no water, or dripping, from which all the water has been driven off by heat. Even ordinary butter contains four-fifths of its weight of pure fat.

There are, then, distinct limits beyond which the concentration of foods cannot be carried, and the idea that 'food tabloids' might be prepared, one or two of which would be the equivalent of an ordinary meal, is seen to be an impossible dream. At the most, all that the maker of concentrated artificial foods can hope to do is to drive off from the natural food the excess of water which it contains, and even then most, if not all, of the original water must be returned to the food before it can be eaten.

It may be questioned, too, **whether the use of highly concentrated foods is physiologically defensible.** The digestive organs are not constructed for the disposal of foods in an extremely compact form. Such forms of nutriment make large demands upon the secretory powers of the stomach, and are apt to be irritating to the digestive organs, in addition to which the total absence in them of 'ballast' renders them unable to supply an adequate stimulus to the peristaltic movements of the intestines. As exclusive foods, therefore, such preparations are eminently unsuitable.

The second object of these substances, that of enabling one **to enrich the diet in certain ingredients**, is more legitimate. Here the artificial food is used simply as an accessory to supplement the lack of proteid, carbohydrate, or fat in other articles of diet. Their small bulk is here a decided advantage, for it enables them to be added to fluid foods without appreciably increasing the total amount of material to be swallowed, and in many cases of illness this is a desirable thing to do.

One may conclude, then, that concentrated foods are only to be used as accessories, and that they have no legitimate place in the dietary of health.

Artificial Proteid Foods.

1. **Undigested**—(*a*) *Of Animal Origin.*—Probably the best of the undigested proteid foods are now derived from casein, the chief proteid of milk. In a previous chapter (p. 139) most of these have been described (Plasmon, Nutrose, Eucasin, Protene flour, etc.).

They have the advantage of being colourless, tasteless, and readily soluble, so that they can easily be added to other foods, besides which they are digested without difficulty and are very completely absorbed.

Of the artificial proteid foods derived from meat, most belong to the predigested class to be considered immediately. Such a preparation of dried meat as **pemmican**, however, may fairly be regarded as belonging to this group, and the same may be said of the dried meat prepared by the Gye and other processes (see p. 160). **Marvis** is a similar preparation prepared from fish (p. 84). It may be regarded as consisting almost entirely of proteid. As has been pointed out elsewhere (p. 105), anyone can, with a little trouble, prepare for himself a powder of dried meat, the nutritive value of which is as high as that of any artificial preparation.

(*b*) *Of Vegetable Origin*.—The chief vegetable proteid foods are **Aleuronat** and **legumin**. The former is a special preparation of glutin containing 80 to 90 per cent. of proteid.[1] It is a yellowish-brown powder, almost insoluble in water, and can be conveniently used as an addition to semi-solid foods. It is largely employed, also, in the feeding of diabetics, and has the advantage of being fairly cheap.

Legumin (vegetable casein) is the chief proteid of pulses, and is a valuable and highly nutritive substance, apt, however, to have a rather bitter taste.

Tropon[2] is a proteid food of recent introduction derived both from animal and vegetable sources, but chiefly from fish and cheap vegetables. It was first prepared by Dr. Finkler of Bonn. It is a brownish powder, free from taste and insoluble in water, but can be easily given if stirred up in thick soups, purées, etc. Three-quarters of an ounce of it contain as much proteid as 4 ounces of beef. It costs 4s. per pound.

2. **Digested Proteid Foods, or 'Peptone Preparations.'**—Before describing the members of this group in detail, one or two preliminary questions must be considered. And firstly it may be asked, Are peptones of as much value in the diet as proteids? Are they equally well assimilated and as capable of repairing tissue waste? At one time some doubt existed about these questions, but now one may say with confidence that peptones *are* fully capable of playing the part in nutrition ordinarily taken by proteids, provided

[1] Supplied by the Protene Co., Welbeck Street, W.

[2] Supplied by Arthur Reiner and Co., Dashwood House, Old Broad Street, E.C.

they be given by the mouth.[1] If injected directly into the circulation, it is true that they are not assimilated, but if taken in the ordinary way they are converted into natural proteids before entering the blood.

It has also been objected that the substitution of peptones for ordinary proteids in the diet must tend to demoralize the stomach by doing some of its work for it, and so render it incapable, through want of practice, of performing its usual digestive functions. This objection seems to be a theoretical rather than a practical one, and with the exception of one experiment by Roberts,[2] on which he did not himself lay much weight, there is little evidence in support of it. Further, it must be remembered that peptones are not intended for the healthy, but for those in whom the stomach is presumably already incapable of doing its work, and in such a case the administration of peptones, by improving general nutrition, might be expected to strengthen rather than to enfeeble the digestive powers.

A much more real disadvantage attending the use of peptone preparations is their tendency to produce diarrhœa, for when introduced suddenly and in large amounts into the stomach and intestine, they seem to induce a large flow of water into the alimentary canal from the blood, and this is accompanied by an increased activity of peristalsis. For this reason they must always be used cautiously and in moderate quantity, while in conditions of diarrhœa the more concentrated forms should be avoided altogether.

It may be questioned, too, whether the cases in which peptones are really required are at all numerous, for an inability on the part of the stomach to digest ordinary proteids properly presented to it, and in a state of fine division, must be regarded as of very rare occurrence. Their place, then, even in the dietary of the sick, is one of quite secondary importance.

Of solid peptone preparations **Somatose**[3] is one of the best examples. Strictly speaking, it consists of albumoses rather than of genuine peptone, but the same is true of the majority of the so-called peptone preparations, and for dietetic purposes albumoses and peptones may be regarded as identical. Somatose is prepared from meat, and occurs as a grayish powder, readily soluble in water and practically

[1] See especially Hildebrandt, *Zeit. f. Physiolog. Chem.*, xviii. 180, 1894; Neumeister, *Deut. Med. Woch.*, xxxvi., 1893; and Von Noorden, *Therap. Monatsheft*, June, 1892.
[2] 'Digestion and Diet,' p. 209.
[3] Supplied by the British Somatose Co., 165, Queen Victoria Street, E.C.

devoid of taste or odour. The following is an analysis of it by Tankard:[1]

Water	14·25	per cent.
Alkali albumin	21·83	,,
Coagulable albumin	3·40	,,
Albumoses	33·96	,,
Peptones	3·06	,,
Meat bases	2·62	,,
Ash	5·30	,,

Roughly speaking, it may be said to contain from 60 to 70 per cent. of building material, and a teaspoonful of it is equal in this respect to about ½ ounce of lean meat. It can be easily added to fluid or semi-fluid foods, but if freely used may produce diarrhœa.[2] The dose recommended is about three or four teaspoonfuls daily, and it seems to be very well absorbed.[3] Like most of the preparations we are now considering, Somatose is rather expensive, an ounce of it costing 1s. 8d., and yielding for that sum only as much nutriment as ¼ pound of beef.

Milk Somatose is a similar preparation obtained from the proteids of milk. It contains 5 per cent. of tannic acid in combination.

Carnrick's Peptonoids is another solid preparation containing predigested proteids. The following is Tankard's analysis of it:[4]

Water	2·13	per cent.
Insoluble proteids	12·22	,,
Albumoses	3·17	,,
Peptones	0·88	,,
Meat bases	2·87	,,
Starch	23·64	,,
Milk-sugar	48·52	,,
Fat	2·00	,,
Ash	4·57	,,

It will be observed that the substance owes its nutritive value to carbohydrates rather than to proteids, and that the larger part of the latter is present in an insoluble form.

[1] Allen's 'Commercial Organic Analysis,' iv. 384.
[2] See Bornstein, *Berlin. Klin. Woch.*, No. 8, 1897.
[3] For literature relating to Somatose and its uses, see Hildebrandt, *Verhand. d. 12ten Cong. f. Inn. Med.*, p. 395, 1893; also references in *Edin. Med. Journ.*, February, 1899, and the *British Physician*, July 15, 1899; also a paper by Stevenson and Luff, *Lancet*, September 30, 1899. The conclusions of the two latter writers are as follows:

i. Somatose is a true meat nutrient possessing restorative and stimulating powers.
ii. It is well borne by delicate patients.
iii. It improves digestion and causes no gastro-intestinal disturbances.
iv. It has a favourable effect on general metabolism.
v. It never gives rise to the appearance of albumin, albumose, or peptone in the urine.

[4] Allen, *loc. cit.*

Mosquera Beef-meal and **Sanose** are solid preparations belonging to this group which have already been described (pp. 105 and 139).

The following tables contain analyses of some of the semi-solid and liquid peptone preparations:

COMPOSITION OF PEPTONE PREPARATIONS (CHIEFLY FROM ANALYSES BY THE AUTHOR).

Preparation.	Water.	Solub'e Proteids (chiefly Albumoses).	Extractives and other Non-proteid Organic Matter.	Mineral Matter.
Koch's Peptone	40·16	34·78	15·93	6·89
Liebig's Peptone[1]	31·9	33·40	24·6	9·9
Brand's Beef Peptone ..	84·6	7·0	—	1·4
Denaeyer's Peptone[2] ..	78·45	12·15	4·32	2·54
Darby's Fluid Meat[3] ..	25·71	30·60	30·18	13·50
Armour's Wine of Peptone	83·0	3·0	12·9	1·1
Fairchild's Panopepton ..	81·0	3·0	15·0 (largely sugar)	1·0
Peptonized Milk[4]	87·5	1·76	10·04 (=sugar, fat, and unaltered proteid)	0·7

[1] Leyden's 'Handbuch der Ernährungstherapie.'
[2] *Ibid.*; see also Von Noorden, *Therap. Monatsheft*, June, 1892.
[3] Horton Smith, *Journ. of Physiolog.*, xii. 42, 1891, and Leyden's 'Handbuch.'
[4] Horton Smith, *loc. cit.*

COMPOSITION OF SOME PEPTONE PREPARATIONS (KÖNIG).

Preparation.	Water.	Total Nitrogen.	Insoluble Proteid.	Albumoses.	Peptones.	Other Nitrogenous Compounds.	Fat.	Ash.
Antweiler's Peptone	6·92	12·85	3·22	14·54	60·15	1·20	0·54	13·31
Kemmerich's Meat Peptone (dry) ..	33·30	9·78	1·10	14·56	32·57	9·97	0·30	7·73
Koch's Meat Peptone (dry)	40·16	7·80	1·42	15·95	18·83	15·96	0·79	6·89
Darby's Fluid Meat ..	25·71	8·06	—	—	30·60	—	—	13·50
Valentine's Meat-juice ..	59·07	2·50	—	1·81	4·87	22·73	—	11·52
Savory and Moore's Fluid Beef	27·01	8·77	—	5·42	2·74	52·73	—	12·10
Benger's Peptonized Beef Jelly ..	89·68	1·55	—	2·41	4·75	2·27	—	0·89

Most of these contain so much water that their nutritive value is comparatively small, while those in which alcohol is present are

open to the same objections as other dietetic or medicinal wines (see p. 369).

Home-made peptonized foods, prepared by aid of such agents as liquor pancreaticus, are now so well known and widely employed that a special description of them is unnecessary.[1] Peptonized milk is that most commonly used. An analysis of it will be found in the foregoing table. Condensed peptonized milk is sold in tins by Messrs. Savory and Moore.

Gruels of various sorts can be prepared in a similar way, peptonized milk gruel being one of the best. Such home-made preparations are mostly to be preferred to commercial articles, and have also the advantage of being very much cheaper.

Artificial Carbohydrate Foods.

Many patent foods which might justly be included in this section have been already dealt with under the cereals, pulses, etc. The only group which remains to be considered is that of the **malt-extracts**. These are prepared by evaporating down an infusion of malted barley at low temperatures or *in vacuo*. The object of evaporating them in that way is to preserve in an active form the diastasic ferment present in the malt; and the special apparatus required for this purpose is one cause of the expense of such preparations.

The following table contains the results of the writer's analyses of some standard malt-extracts:

COMPOSITION OF MALT-EXTRACTS.

	Water.	*Proteid.*	*Carbohydrates and Extractives.*	*Ash.*
Unnamed	2·75	8·4	63·1	1·0 ?
Maltine	33·4	6·09	59·4	1·2
Standard	26·5	7·6	64·9	1·0 ?
D. C. L.	27·5	8·4	63·1	1·0 ?
Kepler	23·4	3·29	72·3	1·0

The average composition of these substances given by Klemperer[2] is as follows:

Sugar	50 to 55 per cent.
Soluble starch	10 „ 15 „
Proteids	5 „ 6 „
Ash	1 „ 2 „

A large dessertspoonful of such an extract weighs about 20

[1] For full details, see Roberts' 'Digestion and Diet,' 2nd edit., p. 192

[2] Leyden's 'Handbuch der Ernährungstherapie.'

grammes, and has a fuel value of 60 Calories, or about as much as an egg

In the above analyses the whole of the nitrogenous matter has been counted as proteid, but it is very doubtful if that is quite accurate. Some of the nitrogen is almost certainly present in other forms.

Malt-extracts may be prescribed with one of two objects: (1) To enrich the supply of carbohydrates in the diet; (2) to aid the digestion of starchy foods by means of the diastase which the extract contains. The advantages possessed by malt-extracts for accomplishing the former of these objects are not quite apparent. **Treacle and golden syrup** both contain a considerably higher percentage of sugar, and are vastly cheaper. It is true that malt-sugar is less apt to irritate the stomach than the cane-sugar which treacle and syrup contain; and although not capable of direct absorption as such, maltose may yet be regarded as a partially digested form of carbohydrate. But in both these respects we have in ordinary honey a superior food.

Honey has the following composition:

Water	16 to 13 per cent.
Invert sugar	78 ,, 74 ,,
Cane-sugar	2·69 ,,
Proteid	1·29 ,,
Ash	0·12 ,,

That is to say, it is actually richer in sugar than malt-extract; and a dessertspoonful has a fuel value of 75 instead of 60 Calories. Furthermore, the sugar of honey is actually in a predigested form, and ready for immediate assimilation. As a source of carbohydrate, therefore, honey is in every way preferable to malt-extracts, besides being a good deal cheaper;[1] and it may be used with great advantage in every case in which one wishes to supplement the supply of carbohydrates in the diet.

The second property of malt-extracts—that of acting upon starch by means of the diastase which they contain—is but rarely present to the mind of the prescriber. The cases in which such an action is desired are not, indeed, at all numerous, and are practically confined to the group of so-called amylaceous dyspepsias. Even in such a case malt-extract is not the best preparation to employ. No matter how carefully the extract may be prepared, it always seems to lose something of its diastasic power in the process (Roberts); and it is far more certain, as well as cheaper, and one may add pleasanter, to make an infusion of malt at home, and either use it as a beverage

[1] Malt-extracts cost about 3s. the pound, honey costs about 9d.

at meals, or, preferably, stir it into starchy foods, such as puddings or gruel, before they are eaten.[1]

The value of **milk-sugar** as a means of supplementing the carbohydrates of the diet must not be forgotten. Its comparative freedom from sweetness makes it specially suitable for such a purpose. If ½ ounce of it is dissolved in 5 or 6 ounces of milk, the nutritive value of the latter is increased by nearly 60 Calories. This may often be taken advantage of in feeding patients with acute fevers.

Artificial Fatty Foods.

In most cases these consist of some kind of fat presented in the form of an emulsion, cod-liver oil being the special variety of fat usually employed.

The object of emulsification is to render the fat more palatable, and also to aid its digestion. The former object is undoubtedly attained; the achievement of the latter is not so certain. It must be remembered that what is now known of the digestion and absorption of fat makes it certain that the process is mainly a chemical one, and not a mere physical absorption of the fat in the form of fine particles. Hence, though emulsification may be a useful preliminary to digestion, fat so presented cannot be regarded as ready for immediate reception into the blood. Like the malt-extracts, therefore, fat emulsions are only partially predigested foods.

The emulsifying agent in these preparations is either an alkaline solution, mucilage, glycerine, or malt-extract. Of these, the three last are to be preferred, for they are unaffected by the acidity of the gastric juice, which is apt to destroy an alkaline emulsion.

An ordinary cod-liver oil emulsion contains about half its weight of fat, and has a fuel value about double that of an equal quantity of malt-extract. The question whether cod-liver oil has any specific virtues other than those of an easily-digested fat cannot be discussed here; but in the case of the purified oils, at any rate, any such specific qualities can hardly be present, unless they be due to cholesterin, the food value of which, however, is very questionable.

A preparation called **Lipanin** has been largely used in Germany as a substitute for cod-liver oil. It consists of ordinary olive oil containing 6 per cent. of oleic acid. The presence of the latter is

[1] Roberts recommends an infusion made by soaking 3 piled tablespoonfuls of crushed malt in ½ pint of cold water overnight, and straining through muslin till clear. It may be preserved in a tightly-corked bottle with the addition of a few drops of chloroform ('Digestion and Diet,' p. 230, where detailed directions for the use of such an infusion are given).

supposed to facilitate emulsification and absorption in the intestine, but experiment has not shown that Lipanin is better absorbed than ordinary forms of fat.[1]

Virol is another cod-liver oil substitute. It is prepared from bone marrow, the yolk of eggs, and malt-extract flavoured with lemon-juice, and has approximately the following composition :[2]

Moisture	11·66 per cent.
Fat	19·72 ,,
Carbohydrates	61·61 ,,
Nitrogenous matter	6·43 ,,
Ash	0·58 ,,

It is an agreeable preparation of very considerable nutritive value, but rather expensive, 2 ounces of it costing 9d.

Pancreatic Emulsion is another pleasant substitute for cod-liver oil. It is made by pounding up lard with pig's pancreas, with the addition of water, straining, and exhausting the strained substance with ether. The ether is distilled off, and the residue of fat is mixed with rectified spirit and water, and emulsified by agitation. Oil of cloves is added to give flavour and aid preservation.

It is not difficult to take, but is no richer in fat than ordinary butter, and considerably more expensive.

Spermaceti used to be largely employed as a means of giving fat, but has now dropped out of use. It was given in the form of a powder mixed with sugar, and ¾ ounce could be taken daily.[3] It is well borne and not difficult to absorb.

The objection to all these artificial preparations is their expense, and for that reason, if for none other, the use of natural fats is preferable. Of these, cream and butter are the most suitable, for there are but few persons who are unable to digest milk-fat. Ordinary **cream** contains about 20 per cent. of fat, and three spoonfuls of it are more than equal in fuel value to one spoonful of cod-liver oil emulsion. **Butter** has 80 per cent. of fat, and can be taken in large quantities if well mixed with starchy foods such as mashed potato. **Almonds** are also a rich source of fat, of which they contain more than half their weight. **Chocolate**, too, has 20 per cent. of fat and 50 per cent. of sugar in addition. Lastly, one should not forget the value of **toffee** as a concentrated form of fat and carbohydrate in about equal proportion. It has the further advantage that much of the sugar which it contains is in the easily digested 'invert' form. It may be specially recommended in the case of children who are

[1] See Leyden's 'Handbuch der Ernährungstherapie,' p. 302.
[2] Analysis supplied by the makers.
[3] See Senator, *Berlin Klin. Woch.*, No. 13, 1887.

unable to take cod-liver oil or other forms of fat, and if given only at the end of meals is not likely to do any harm. If the merits of some of these natural forms of fat were rightly appreciated, there would be but little need to have recourse to artificial preparations.

2. Artificial Feeding.

Rectal Feeding and Nutrient Enemata.

Rectal feeding has constituted a therapeutic resource ever since medical science existed,[1] but it is only within recent times that the value of this method of administering nourishment has been subjected to careful scientific scrutiny.

The absorptive power of the large intestine for **proteids** has been investigated by Eichhorst,[2] Leube,[3] Brandenburg,[4] Huber,[5] Ewald,[6] Plantenga,[7] and others. Their results show that: (1) Peptone is well absorbed; (2) milk proteids are not well absorbed (though Eichhorst got a contrary result); (3) eggs given alone are not well absorbed, but if 15 grains of salt are added to each egg they are almost as well utilized as if they had been peptonized; (4) raw-beef juice is very completely absorbed; (5) albuminoids such as gelatin are not absorbed.

As regards **carbohydrates**, it has been found that sugars are well absorbed, but are apt in concentrated solution to prove irritating to the mucous membrane. Leube advises that the solution should not be stronger than 10 to 20 per cent., and that not more than 300 c.c. should be given at one time. Even then there is a risk of the enema being very soon returned. Curiously enough, starch seems to be fairly well absorbed, even when given in the raw state: 50 to 100 grammes of it may be given in 300 c.c. of water. It is not at all irritating.

Fats are not at all well absorbed when given by the bowel.[8] The total amount absorbed depends on: (1) The absolute quantity administered; (2) its length of stay in the bowel; (3) the temperature of the enema and the presence or absence in it of common salt. Not

[1] For a sketch of the history of the subject, see the valuable monograph by Dr. A. P. Gros, 'Traitement de certaines Maladies de l'Estomac par la Cure de Repos absolu,' etc.; Paris, 1898.
[2] *Archiv. f. Physiolog.*, iv. 570, 1871.
[3] Leyden's 'Handbuch der Ernährungstherapie,' p. 496 *et seq.*
[4] *Deut. Archiv. f. Klin. Med.*, lviii. 71, 1896.
[5] *Ibid.*, xlvii. 495, 1891.
[6] *Archiv. f. Anat. und Physiolog.*, Supp. Bd., p. 160, 1899.
[7] *Centralbl. f. Physiolog.*, No. 22, p. 734, 1899 (abstract of dissertation); see also Gros, *op. cit.*
[8] See Deucher, *Deut. Archiv. f. Klin. Med.*, lviii. 210, 1897.

more than 25 grammes of fat should be given at once, and with at least as much water. The enema should be given at the body temperature, and enough salt added to form a normal saline solution. The bowel should be empty, and only one enema given daily. Even under these favourable conditions, not more than 10 grammes of fat are likely to be absorbed daily.

It follows from these experimental results that the best ingredients for nutrient enemata are: (1) Peptones or albumoses; (2) eggs, with the addition of salt; (3) raw-beef juice; (4) dilute solutions of grape-sugar; (5) unboiled starch. To this list should be added alcohol, which is perhaps better absorbed by the large intestine than anything else except water.

It may be admitted that the capacity of the large intestine to absorb some of these articles is not easy of explanation. It is pretty clearly established that the colon secretes no digestive ferments. How, then, it may be asked, is it capable of absorbing such substances as egg-white and unboiled starch? There is one easy way out of the difficulty, and that is by assuming the occurrence of a **reverse peristalsis**, which carries substances injected into the rectum up above the ileo-cæcal valve into the small intestine. That such a reverse peristalsis is possible is, I think, no longer open to doubt. It is proved by the experiments of Grützner,[1] by the observations of Nencki, Macfadyen and Sieber on a patient with a fistula at the lower end of the ileum,[2] and by the incontestable fact of the occasional vomiting of enemata by hysterical patients.[3]

It is very probable that in this way a part at least of a nutrient enema gets carried into the small intestine, where absorption can readily occur. Variations in the patency of the ileo-cæcal valve may explain the different degrees to which different individuals absorb such enemata.

Special emphasis must be given to the great extent to which **the addition of salt to nutrient enemata** promotes their absorption. This is a practical matter of the first importance. Its *modus operandi*, however, is not easy of explanation. It may perhaps stimulate the appearance of the reverse peristalsis above referred to, or it may excite the intestinal cells to greater absorptive efforts, while it undoubtedly facilitates the diffusion of the enema over the surface of the bowel.

Putting aside these rather academical discussions, there is abundant

[1] *Pflüger's Archiv.*, lxxi. 492, 1898.
[2] *Archiv. f. Exper. Path. und Pharmak.*, xxviii. 311, 1891.
[3] Gros, *op. cit.*, chap. iv.

clinical evidence for the feasibility of nourishing patients, for some time at least, by the rectum exclusively. In several cases cited by Gros, patients were fed by this method alone for as long a period as three weeks, and with but little loss of weight.[1]

The process, however, cannot be continued indefinitely, for, apart altogether from the fact that the rectum sooner or later becomes intolerant, one can hardly hope, allowing for deficient absorption, to get more than 500 Calories of energy into the blood daily by this means, and that is only about a quarter or at most one-third of the amount required even by patients who are kept very warm and at absolute rest.

Milk is most commonly used as the basis for enemata, as it is simple, convenient and unirritating, in spite of the fact that only about one-third of the casein which it contains is absorbed. The following are some of the formulæ for enemata containing milk recommended by Leube[2]:

Peptone and Milk Enema.

Peptone, 60 grammes.
Milk, 250 c.c.

Egg and Milk Enema.

3 eggs.
3 grammes of common salt.
Milk, 250 c.c.

Sugar and Milk Enema.

Grape-sugar, 60 grammes.
Milk, 250 c.c.

Starch and Milk Enema.

Starch (unboiled[3]), 60 to 70 grammes.
Milk, 270 c.c.

It might be well to peptonize the milk first. Somatose may be used instead of peptone.

Red wine is recommended as an addition by many Continental writers. The alcohol which it contains is readily absorbed, while its astringency and slight acidity seem to favour retention of the enema. The following formulæ are examples:

Enema of Eggs, Sugar, and Wine.

2 to 3 eggs.
1 glass of red wine.
20 per cent. grape-sugar solution, 1 cupful.
(The addition of 3 grammes of salt would probably be an improvement.)

[1] See also Ewald, *Archiv. f. Anat. und Physiolog.*, Supp. Bd., p. 160, 1899, and Rost, *Berlin. Klin. Woch.*, pp. 660, 686, 1899.
[2] 28 grammes, or 28 c.c. = 1 ounce.
[3] Boiled starch is too thick to inject.

The above is the enema used by Ewald. Gros recommends the following:

Boas' Enema.

Milk, 250 c.c.
Yolks of 2 eggs.
A pinch of salt.
Red wine, 15 c.c.
Starch or arrowroot, 15 grammes.

Riegel's Enema.

Milk, 250 c.c.
2 to 3 eggs.
2 to 3 pinches of salt.
Red wine, 30 c.c.

Tournier's Enema.

Beef-tea,[1] 140 to 150 c.c.
The yolks of 6 eggs.
2 small spoonfuls of salt.
Red wine, 20 to 40 c.c.

The eggs should be beaten up for at least five minutes, so as to mix them thoroughly.

Leube's Pancreas Enema is an attempt to imitate natural intestinal digestion. It consists of a mixture of chopped pancreas and lean meat, with the addition of some fat, in the following proportions:

Pancreas	50 to 100 grammes.
Meat	150 ,, 300 ,,
Fat	30 ,, 45 ,,

The pancreas and meat should both be free from fat, and chopped as finely as possible. They are stirred up in a basin with a large spoon, 150 c.c. of lukewarm water being added. The fat should be mixed with the mass in a mortar very thoroughly by aid of a warm pestle.

Leube claims that this enema is unirritating and well retained, and that the fat in it is freely absorbed and can be demonstrated in the cells of the large intestine in the form of droplets. No starch should be added, for sugar is produced from it so rapidly that it irritates the mucous membrane of the bowel.

General Technique.

Enemata should be given at the body temperature, and their bulk should not exceed 250 c.c. (about 9 ounces). Fluids should be given through a soft œsophageal tube of small calibre, introduced as high as possible, and connected with a funnel raised to a height of 3 feet. Thicker mixtures (such as the pancreas enema) should be adminis-

[1] Raw-beef juice would be better.

tered by means of an ordinary enema or pressure syringe. The enema should be given slowly, and the patient should lie quiet for an hour after it has been injected. Three or four enemata in the twenty-four hours is a sufficient quantity, and one cleansing injection should be given daily, for absorption is greatly promoted by having the surface of the mucous membrane clean. If the enema is badly retained, a little opium may be added.

One must persevere even if the first few injections are returned, and try to find amongst the above formulæ one that suits the particular case.

Nutrient suppositories cannot be recommended. They usually contain peptone, but at most not more than 125 grains in each, which means, even assuming complete absorption, an energy value of less than 35 Calories. The absorption of such suppositories has been found in some cases to be very far from perfect.

SUBCUTANEOUS FEEDING.

The injection of nutritive substances under the skin may be regarded as the latest method of administering food artificially. It was first introduced by Menzel and Perco in the year 1869,[1] but has only come into use very slowly since that date.

In order that a food may be available for subcutaneous administration, it must **fulfil three conditions**:

1. It must be capable of direct assimilation.
2. It must be unirritating.
3. It must be of such a nature that it can be easily sterilized.

There are but few foods which meet all these requirements.

Most **proteids** are unsuitable, because those which can be directly assimilated by the tissues are not easily sterilized without undergoing coagulation; and, on the other hand, those which can be readily sterilized, *e.g.*, peptones and albumoses, are not directly appropriated by the tissues, and even act as poisons to them.[2]

Serum, however, contains proteids in a form in which they can be sterilized without much difficulty, and which are directly assimilable. If serum is heated to 55° C., it becomes opalescent, but does not coagulate, and can then be injected without danger.[3]

[1] For the history of subcutaneous feeding, see Bauer, 'The Dietary of the Sick' (Von Ziemssen's 'Handbook of General Therapeutics,' vol. i.), p. 271, and Leube in Leyden's 'Handbuch der Ernährungstherapie,' i. 513.

[2] See Neumeister, *Deut. Med. Woch.*, No. 36, 1893.

[3] Friedenthal and Lewandowsky, *Archiv. f. Anat. und Physiolog.*, Heft. 5, 6, p. 531, 1899.

Reinach[1] brought round children who were very much exhausted by diarrhœa by injecting 20 c.c. of ox serum under the skin at the sides of the thorax. This quantity, however, contains only about 1½ grammes of proteid, and it is probable that the injection of salt solution would have an equally favourable effect.

Horse serum contains from 7½ to 8 per cent. of proteid,[2] and is a more suitable form for administration in this way. Salter[3] has injected as much as 100 to 120 c.c., previously heated to 65° C., of it under the skin in adults without any bad effects. No albuminuria appeared, and the total nitrogen excretion in the urine was increased. The total amount of proteid which can be administered by this method, however, can never be of much nutritive importance.

Carbohydrates in the form of grape-sugar are easily sterilized, and can be directly assimilated. F. Voit[4] found that as much as 60 grammes of grape-sugar in 10 per cent. solution could be injected under the skin of the thigh without glycosuria resulting. Unfortunately, however, sugar solutions are irritating, and much pain and infiltration are apt to be produced at the site of injection. Müller,[5] for instance, injected a 10 per cent. solution under the skin of his own thigh, but so much pain was produced that he resolved never to try the experiment again. Leube[6] states that at most 15 to 20 grammes of grape-sugar can be injected without great pain resulting.

Fat, in the form of oil, is really the only form of food which fulfils all three conditions, and accordingly it is the only food substance which can be injected under the skin with any freedom. The dangers of producing fat embolism would seem to be imaginary. Leube, after a very considerable experience, has never seen it occur.

Olive and sesame oils are the best forms to use: 30 to 40 c.c. should be injected with a 10 c.c. syringe at three different places, the injection being performed slowly and without much pressure, and the puncture sealed with collodion. Injection should be performed only once a day, and the groin is perhaps the best site to select.

That oil so injected is really assimilated is evidenced by the fact that the excretion of nitrogen is lessened by it,[7] and post-mortem also the fat is found to have disappeared from the point of injection.

1 *Berlin. Klin. Woch.*, March 20, 1899.
2 Szontagh and Wellmann, *Deut. Med. Woch.*, No. 27, 1898.
3 *Guy's Hospital Reports*, liii. 241, 1896.
4 *Münch. Med. Woch.*, August 4, 1896, and No. 31, 1897.
5 Gumprecht, *Verhand. d. Cong. f. Inn. Med.*, p. 124, 1898.
6 *Verhand. d. Cong. f. Inn. Med.*, p. 418, 1895.
7 G. Sommer, 'Stoffwechselversuch mit Subcutaner Fettinjection am Menschen,' *Sitzungsber. d. Physik. Med. Gesell. zu Würzburg*, No. 2, p. 26, 1897.

If the oil be properly sterilized, no local irritation is ever produced, and the injections may be continued for as long as four weeks without bad results.[1]

Caird[2] reports a case of stricture of the œsophagus in which the patient was going downhill under enemata, and had a subnormal temperature. Four ounces of sterilized olive oil were injected into the gluteal muscles without the production of any local pain or discomfort, and with great benefit to the general condition.

Krueg also kept a lunatic alive for twenty days without loss of weight by the subcutaneous injection of 15 to 30 c.c. of olive oil daily,[3] and other observers have repeated his experience.[4]

There can be no doubt, then, that feeding by means of the subcutaneous injection of sterilized oil is a feasible enough proceeding, but it must be remembered that its value is strictly limited. The indefinite prolongation of life upon it is impossible, for man cannot live by fat alone, and in any case it can hardly supply more than 500 Calories of energy daily, or about a quarter of the total required. The chief use of the subcutaneous administration of fat, indeed, would appear to be as an accessory aid to nutrition in those cases in which a moderate amount of proteid can be administered per rectum. In such cases it is undoubtedly a valuable resource.

The **subcutaneous administration of yolk of egg** has recently been practised by Muggia[5] in cases of malnutrition in infants and as a substitute for lecithin. The injection is prepared by mixing the yolk of a fresh egg with one-third of its weight of normal saline solution. The mixture is stirred with a glass rod in a previously sterilized vessel, and then strained through gauze. The initial dose is 1 c.c., the injections being made in the buttock or lumbar region. There is no local or general reaction provided aseptic precautions are observed. Gentle massage is performed after the injection. The quantity at each injection may be gradually increased up to 10 c.c., but one should not go above that. He states that the general nutrition and condition of the blood are improved more rapidly under this treatment than under lecithin.

[1] See Jacob, quoted by Gumprecht. *Verhand. d. Cong. f. Inn. Med.*, p. 124, 1898.
[2] *Edin. Med. Journ.*, September, 1893.
[3] See Lilienfeld, *Zeit. f. Diät. und Physik. Therapie*, ii. 209.
[4] For example, Fornace and Micheli, *Rif. Med.*, July 14 and 15, 1897 (abstract in *Brit. Med. Journ.* Epit., September 11, 1897).
[5] *Brit. Med. Journ.* Epit., September 30, 1899.

Gavage and Forced Feeding.

Gavage was introduced by Debove in the year 1881.[1] The term was first applied to the method of introducing food into the stomach by means of a tube in cases of obstinate vomiting. Curiously enough, food so introduced is often retained when nourishment swallowed in the usual way is vomited immediately. The meaning of the term has now been extended so as to cover all cases in which food is artificially introduced into the stomach by a tube in excess of the demands of appetite, a proceeding more correctly described as **forced feeding**.

An ordinary soft stomach-tube is employed, and it is only necessary to introduce it into the upper part of the œsophagus; it need not enter the stomach proper. If the pharynx is very sensitive, it may be previously anæsthetized by cocaine.

A mixture consisting of 1 or 2 pints of milk, 3 beaten-up eggs, and 3 ounces of milk-sugar will be found very suitable for administration in this way. Dujardin Beaumetz speaks very highly of powdered meat, of which he gives 100 to 400 grammes daily, stirred up in milk, chocolate, or soup.

A daily ration consisting of 3 pints of milk, to which have been added 3 ounces of milk-sugar (previously dissolved in water by boiling), ½ pint of cream, and a pint of soup strengthened by some proteid preparation, such as Nutrose, Plasmon, Tropon, or powdered meat, will be amply sufficient to maintain the nutrition of a patient who is confined to bed, and is very easily administered by the tube.

[1] See Dujardin Beaumetz, *Clinique Thérapeutique*, i. 402

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THE END

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